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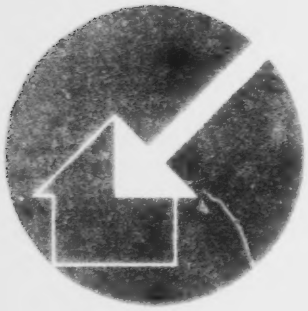

SOLAR ENERGY PROGRAM

CONTRACT REGISTRY 1983–1984

NRCC No 23526

JULY 1984

Canada

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SOLAR ENERGY PROGRAM

CONTRACT REGISTRY

1983-1984

PUBLISHED BY

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NATIONAL RESEARCH COUNCIL CANADA

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INTRODUCTION

This Contract Registry contains a description of all contracts, issued by the Solar Energy Program, National Research Council of Canada, that were either completed or ongoing in the period from August 1, 1983 to April 30, 1984. The contracts have been grouped into five categories corresponding to our sub-program structure. These are:

A. Residential active
B. Passive
C. Commercial/industrial process heat
D. Photovoltaics
E. Core applications

The last category is strictly administrative and information studies but some core activities have been included.

Within each category contracts are grouped according to the type of study. Some flexibility has been allowed in the defintion of these groupings and the specific classifications are reflected in the Table of Contents (p. v). The general categories are as follows:

Category No.	Type of Study
1 & 2	Technical, economic, and information studies
3 & 4	Materials, technology, and product development
5	Systems development
6	Simulation and design tools
7 & 8	Perfomance evaluation
9	Test methods and standards

A new publication section has been added to this year's Contract Registry. This contains a listing of reports which have recently been published by the Solar Energy Program, a list of pertinent Division of Building Research publications, and information on ordering all reports referenced in the "Reports and Reference Sources" sections on the summary sheets.

As in other years the contributions of each of the Project Scientists and Managers of the Solar Energy Program are essential to the production of this Contract Registry and I thank each one of them. I would be glad to receive any comments or suggestions regarding this publication.

Joan E. Hill
Technical Liaison Officer
Solar Energy Program
July 1984
(613) 993-9224

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A.4	Lion Industries	Development of a proportional demand heater for solar domestic hot water systems. Phase II - Product development	2-2643	6
	Petro-Sun	Development of a modular low temperature solar collector	2-2645	7
	North Star Engineering Products	Development of an improved fin system for solar collectors employing heat pipe technology	2-2864	8
	Amherst Renewable Energies	Improved structural integrity for a glazed plastic solar collector	3-3010	9
	Solarsystems Industries	Upgrading of continuous black chrome plating line to process thin copper foil and to investigate electroforming of copper foil	3-3036	10
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	General Solar	Development of an improved solar domestic hot water system	2-2624	14
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	SolWay Solar Engineering	Design and construction of an improved solar domestic hot water system. Phase II	2-2735	17
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	Resource Ventures	Study, evaluation, and monitoring of a low-cost DHW system	3-0063	45
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	Ontario Research Foundation	Preparation of design drawings, specifications, and cost estimates for the proposed extension of the National Solar Test Facility	3-5021	189

How to Obtain Publications

All available references listed in the 'Reports and Reference' section of the summary sheets can be borrowed from Canada Institute for Scientific and Technical Information (CISTI) by either visiting the Energy Library, National Research Council, Montreal Road, Bldg. R-105, or through Interlibrary Loan. This latter service is available through your local library, be it company, university, government, or public. If the services of a library are not available you may write or telephone:

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A remittance in the form of a cheque or money order payable to the Receiver General for Canada, credit NRC, should accompany your order.

Reports published prior to September 1983 are still available. For a listing of these reports, the "Solar Energy Program Publications List", February 1984 edition, may be obtained free of charge from Publications Sales and Distribution.

PUBLICATIONS LISTED IN CONTRACT REGISTRY 1983-1984

Report No.	Description	Page
CENSOL 1	V.G. Chant and R.C. Biggs. Tools for design and analysis. James F. Hickling Management Consultants Ltd. March 1984. 157 pp. $12.00.	3
CENSOL 2	V.G. Chant and R. Hakansson. The MINSUN simulation and optimization program application and user's guide. IEA/CSHP Task VII. James F. Hickling Management Consultants Ltd. December 1983. 210 pp. $12.00.	3
Coll-17-D	P.A. Irwin, S.L. Gamble and M.F. Lepage. Snow and wind loads resulting from roof mounting of solar collectors. Morrison, Hershfield, Theakston and Rowan Limited. July 1984. 74 pp. No charge.	109
Instal-2 Part 1	R.J. Brandon and P.R. MacKinnon. Field trial of solar domestic hot water systems. Institute of Man & Resources. January 1982. 40 pp. $5.00.	36
Instal-2 Part 2	R.J. Brandon and P.R. MacKinnon. Field trial of solar domestic hot water systems. Institute of Man & Resources. January 1982. 60 pp. Out of print.	36
IPH-2-D	D.B. Brooks & R. Peters. Information background for an R&D plan for commercial, institutional and industrial process solar technology. Marbek Resource Consultants Ltd. July 1984. 45 pp. No charge.	117
Passive-7	L. Jones. Review of potential of passive solar strategies for office buildings. Leslie Jones & Associates Inc. August 1983. 171 pp. $7.50.	49
Passive-8	B. Hamilton & R. Alward. Level B monitoring manual. Memphremagog Community Technology Group. April 1984. 261 pp. $14.50.	101
Passive-9	M.N. Bahadori. Natural ventilation systems for passive cooling. Building Engineering Group, University of Waterloo. April 1984. 92 pp. $7.00.	56
Passive-10	J.E. Ferguson & J.L. Wright. VISION: A computer program to evaluate the thermal performance of super windows. Spider Engineering Associates. August 1984. 90 pp. $7.00.	95

Report No.	Description	Page
Passive-11	P. West. Passive solar options for an energy efficient condominium apartment building. Engineering Interface Limited. March 1984. 62 pp. $5.50.	62
Passive-12-D	E. Cuplinskas. Evaluation of graphic manual methods for passive design. Okins, Leipciger, Cuplinskas, Kaminker Ltd. To be published. Fall 1984.	91
Sim-8	S.C. Carpenter and M.J. Chamberlain. A computer parametric study of thermosyphon SDHW systems. Enermodal Engineering Ltd. October 1983. 52 pp. $5.50.	34

OTHER SOLAR PUBLICATIONS OF INTEREST

S. Carpenter and M.S. Chamberlain. "Examination of several methods of improving the performance of direct gain passive solar heating systems". 9th Annual Conference. Solar Energy Society of Canada Inc. Windsor, Ontario. Aug. 1-5, 1983. Paper No. PS1. Published by the Solar Energy Society of Canada Inc. Winnipeg. 1983. 51

W.E. Carscallen, M. Chandrashekar, H. Taube, and H.G. Okrafka. "Performance and operation of a drain back evacuated tubular collector array at the Mountain Spring Bottle Washing Facility". Presented at the International Energy Agency "Workshop on the Design & Performance of Large Solar Thermal Collector Arrays". San Diego, California. June 10-14, 1984. Proceedings to be published. 147

M. Glover. R&D plan for passive solar. Overview and Update #4. Solar Energy Program. June 1984.

Expected in October 1984:
- R&D plan for commercial and industrial process heating
- R&D plan for residential active solar heating

DIVISION OF BUILDING RESEARCH PUBLICATIONS

Report No.	Description
BRN No. 184	S.A. Barakat and D.M. Sander. Utilization of solar gain through windows for heating. March 1982. 11 pages. No charge.
BRN No. 188	S.A. Barakat. Passive solar heating studies at the Division of Building Research. November 1982. 11 pages. No charge.
BRN No. 195	S.A. Barakat and D.M. Sander. A simple method for determining the heating requirements of direct-gain passive solar houses. September 1982. 10 pages. No charge.
NRCC 18674	S.A. Barakat. Solar heat gains through windows in Canada. Division of Building Research Paper No. 944. October 1980. 60 pages. $2.75.
NRCC 23052	S.J. Harrison and S.A. Barakat. A method for comparing the thermal performance of windows. 1983. 9 pp. $1.00.
NRCC 23053	D.M. Sander and S.A. Barakat. A method for estimating the utilization of solar gain through windows. 1983. 11 pp. $1.25.

RESIDENTIAL ACTIVE

SECTION A

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NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Feasibility study on storing and collecting energy using the latent heat of fusion of ice	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-1-2644E
STATUS: COMPLETED	
CONTRACT START DATE: 82 12 01	COMPLETION DATE: 83 12 29
CONTRACTOR: Sunwell Engineering Company Ltd. 18 Kiliaioe Road, Unit 4 Concord, Ontario L4K 1C8	PRINCIPAL INVESTIGATOR: V. Goldstein (416) 738-1222
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $37 516	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

After surveying work published on the storage and collection of energy using the latent heat of fusion of ice, including ice generation methods, binary solutions, storage methods, compressors, condensers, solar collectors, and six types of commercial ice-making and ice-storage equipment, the physical criteria affecting the design of such a heat-storage system were studied. A system was conceived and modelled mathematically using Toronto weather data.

The melting point of ice is lower than ideal for most systems, but water is usually cheaper than other phase-change materials and has no decomposition problems. The Sunwell ice-generation system has many advantages which include the ice being pumpable, good heat transfer because of the tiny thickness of the ice (the crystals are about 0.06 mm in diameter) and high surface area, no need for agitation, immediate ice production, and almost total freedom from mechanical wear.

A system was designed consisting of an 11 kW condensing unit at -9°C, a 60 g/s ice generator, a 300 cm^3/s slurry pump, a storage tank for 2.3 Mg of ice and a 50 m^2 solar array. The system is capable of very high efficiencies because solar collection mostly occurs at below ambient temperatures, and unglazed solar collectors may be used.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, storage, ice/water, phase-change

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Cost-effectiveness of packaged solar DHW systems in small multi-family dwellings		
OERD REFERENCE NO:	4.2.1	CONTRACT NO:	02SX.31155-2-2622
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	82 07 21	COMPLETION DATE:	84 07 30
NEXT MILESTONE & DATE:	84 07 30		

CONTRACTOR:	PRINCIPAL INVESTIGATOR:
IEA Consulting Group Ltd. 162 Richmond Street, Box 2888 Charlottetown, P.E.I. C1A 8C5	R. Brandon (902) 892-4067
NRC PROJECT MANAGER:	**NRC PROJECT SCIENTIST:**
T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	B. Sibbitt Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE:	**FUNDING AGENCY:**
$51 665	Solar Energy Program National Research Council Canada Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

A market segment for solar domestic hot water (SDHW) heating that requires further analysis is the small multi-family dwelling such as the duplex or triplex. These areas might prove to be significant for the Canadian solar industry if it could be shown that financial savings exist and if some major institutional barriers could be overcome.

The project is divided into two phases, with the second, implementation phase, conditional on a promising conclusion from the initial background study phase. The objectives of the work will be to first determine the economic case for the installation of SDHW systems in multi-family sites. It is expected that although the analysis will concentrate on Maritime housing stock, much of it will prove applicable to other areas of Canada. A second objective will be to consider the major institutional barriers blocking the introduction of the technology and to propose methods to overcome these barriers.

The Phase II objective would be to test these approaches in the market place by providing technical and monitoring support to projects that would be partially funded by the private sector.

KEY WORDS: Solar, domestic hot water, market analysis, multi-family dwelling

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Support to Canadian participation in IEA/CSHP Task VII, Phase I	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2706
STATUS: IN PROGRESS AS OF: 84 06 09	
CONTRACT START DATE: 83 01 31	COMPLETION DATE: 84 03 31
CONTRACTOR: James F. Hickling Management Consultants Ltd. #605 - 350 Sparks Street Ottawa, Ontario, K1R 7S8	PRINCIPAL INVESTIGATOR: V. Chant (613) 237-2220
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $123 951	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT PRECIS

Canada, through NRC/SEP, is a participant in this IEA Task VII, Central Solar Heating Plants with Seasonal Storage, Feasibility Study and Design. Canada carries lead country responsibility in sub-task 1(a), Systems Studies and Optimization. This contract provided support to this effort through: 1) development, modification, documentation, and distribution of the simulation programs, MINSUN and TRNSYS; 2) performance of the Canadian Case Study; 3) analysis and reporting on the results from case studies as part of sub-task 1(a); and 4) conducting the Canadian location specific feasibility study as Canada's input to the 1(e) sub-task.

Two IEA reports were published in spring '84 as final documentation of sub-task 1(a) Task VII, namely:

"Tools for design and analysis", CENSOL 1, and "The MINSUN simulation and optimization program application and user's guide" CENSOL 2.

These reports cover the major accomplishments of this contracts.

REPORTS AND REFERENCE SOURCES: The two reports CENSOL 1 and CENSOL 2 are available from Publication, Sales & Distribution, National Research Council, Montreal Road, Building R-88, Ottawa, Ontario K1A OR6 or on loan from CISTI.

KEY WORDS: Seasonal storage, central plants, IEA

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Feasibility study of the application of fluid logic devices to solar panel flow control	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 06ST.31926-3-0052
STATUS: COMPLETED	
CONTRACT START DATE: 83 06 13	COMPLETION DATE: 84 05 08
CONTRACTOR: Waterloo Research Institute University of Waterloo 200 University Avenue West Waterloo, Ontario N2L 3G1	PRINCIPAL INVESTIGATOR: H.R. Martin Faculty of Engineering (519) 885-1211
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $10 005	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of the work performed was to provide design background to development of fluidic power circuits using plastic piping and components, to review the potential of a particular design, and to review the suitability of existing fluidic and moving-part devices for freeze-protection applications. The solar domestic water heater problem is defined and the fundamentals of fluid power are described. Fluidic (or flueric) logic components were compared with equivalent moving-part components.

A method, called TUTSIM, of simulation of continuous dynamic systems suitable for personal computers is described, and it was used to simulate the design above, when modified by the addition of a differential accumulator. The design as modified should prove satisfactory.

It was concluded that the use of small-bore flexible plastic tubing can greatly reduce the cost of retrofitting systems. Most of the work done on fluidics applies to gas flow, so it is difficult to apply existing information to the control of liquids. A totally flueric power circuit is not feasible, because of flueric pressure-relief valve is not available, and most flueric components, except for the vortex diode, are too leaky.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Solar, drain down, fluid logic device

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Thermal and economic evaluation of PV pumped SDHW systems

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	04SR.31926-4-5003
STATUS: IN PROGRESS AS OF:	84 03 31		
CONTRACT START DATE:	84 03 07	COMPLETION DATE:	84 06 29
NEXT MILESTONE & DATE:	84 06 29		

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
B.E. Sibbitt
Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-2730

CONTRACT PRICE:
$16 963

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to establish the thermal and economic advantages or penalties associated with photovoltaic pumped solar domestic hot water systems relative to their conventional active counterparts.

The approach is to first survey product literature and then to modify the SYPHON program to model photovoltaic systems. The thermal performance of the PV-SDHW system will be simulated and the cost-effectiveness of this system compared to a thermosyphon system and a conventional active system.

KEY WORDS: Solar, DHW, PV, water pumping, simulation

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of a proportional demand heater for solar domestic hot water systems. Phase II - Product development.
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31155-2-2643
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 02 28	COMPLETION DATE: 85 01 31
NEXT MILESTONE & DATE: 85 01 31	

CONTRACTOR: Lion Industries Ltd. 6-1329 Niakwa Drive Winnipeg, Manitoba R2J 3T4	PRINCIPAL INVESTIGATOR: J.R. Lion (204) 257-7278
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $37 959	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A production prototype of a proportional demand heater for use in solar domestic hot water heaters is to be developed.

This will include: the design of a helically wound heater element and of the tank in which it is contained; development of a flow switch prototype using a Hall Effect sensor; improvement of the control circuit to incorporate anticipation and to refine the temperature control; and design of the enclosure to house the components ensuring compactness and ease of installation.

Two units will be assembled and subjected to abnormal testing as required by CSA specification C22.2 No.46 and then tested on a two-minute cycle for 180 days under normal conditions.

KEY WORDS: Solar, domestic hot water, proportional heater

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a modular low temperature solar collector

OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31155-2-2645
STATUS: IN PROGRESS AS OF: 84 04 09	
CONTRACT START DATE: 83 03 31	COMPLETION DATE: 84 06 10
NEXT MILESTONE & DATE: 84 06 10	

CONTRACTOR: Petro-Sun Incorporated 5035 Timberlea Blvd., Unit 5 Mississauga, Ontario L4Y 2N5	PRINCIPAL INVESTIGATOR: John T. Pappain (416) 624-5591
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $80 537	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

An improved low temperature solar collector is to be designed incorporating the following features: modular design allowing a variety of panel widths; simple means of supporting the collector away from the roof to avoid moisture damage; reduced wind loading; improved structural integrity; and an improved method of fastening the panel to the support structure.

Alternate designs for the absorber profile which will eliminate stress concentrations while increasing wall thickness will be developed. The design is to use a die significantly smaller than the current one, will incorporate a built-in fastening device, and must take into account the assembly process to be used (connecting clips or heat sealing). A tool maker will be selected to make test dies which will then be tested on an extruder. The absorber sections produced will be tested for consistent and accurate wall thickness and for strength. The most acceptable set of dies will be selected and modified as necessary. Assembly options will be evaluated and modifications to the assembly process designed to accommodate the new absorber plate profile.

KEY WORDS: Solar, collector, fabrication

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of an improved fin system for solar collectors employing heat pipe technology	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2864
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 83 02 25	COMPLETION DATE: 84 07 31
NEXT MILESTONE & DATE: 84 07 31	
CONTRACTOR: North Star Engineering Products Ltd. 2285 Ekers Avenue Montréal, Québec H3S 1C6	PRINCIPAL INVESTIGATOR: Frederick Milz (514) 733-8560
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $71 782	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The heat pipe solar systems developed under contract 02SX.31155-0-2690 by Brace Research Institute are to be improved to make the systems suitable for factory production at a reasonable cost. The earlier contract showed that the two systems (one with a thermosiphon tank for domestic hot water applications, one with a header arrangement for process heat applications) both work well and confirmed that heat pipes are freezeproof, withstand stagnation temperatures, have short time constants, and act as thermal diodes.

A theoretical analysis is to be carried out to determine the collector heat loss, heat output, and heat transfer rates at the heat pipe/absorber fin, absorber fin/header, and absorber fin/batch tank interfaces. The combined fin design will then be optimized. Two versions of the solar collector system (header and batch tank) are to be designed, constructed, and tested at various tilt angles under different weather regimes.

KEY WORDS: Solar, collector, heat pipe

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NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Improved structural integrity for a glazed plastic solar collector	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31926-3-3010
STATUS: COMPLETED	
CONTRACT START DATE: 83 09 16	COMPLETION DATE: 84 04 27
CONTRACTOR: Amherst Renewable Energies Box 387 Perth, Ontario K7H 3G1	PRINCIPAL INVESTIGATOR: R.W. Davies (613) 820-3274
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $24 929	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

Although thermally the Solartronics solar collector performed well for swimming pool heating, mechanically it suffered a high failure rate, attributed to embrittlement of the plastic back sheet due to the solvant bonding process used in panel manufacture. The fluid passage configuration was redesigned to halve the maximum passage size. A bayonet type coupling with improved compliance to thermal dimensional changes was developed.

Impact testing showed that back sheets from panels made in the normal production manner, but separated before they were properly bonded, had only one quarter of the strength of the virgin plastic ("Noryl", polyphenylene oxide), but panels only heated, or only stressed, or only sprayed with solvant, as in production, retained at least 85% of the original strength. Back sheets taken from panels made on a device that was built to apply solvent only to the areas to be bonded retained 75 to 85% of their original strength.

Heat bonding equipment was studied and sample bonds were made using ultrasonic, electomagnetic and vibration welding. The first two were too slow and too expensive, and the third would not work on such flexible components. Prototype panels of the revised configuration, compatible with existing systems, bonded by drawing a vacuum on both sides of the back sheet retained about 80% of the strength of the virgin plastic.

REPORTS AND REFERENCE SOURCES: Copies of the executive summary are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A OS2

KEY WORDS: Solar, collector, manufacture

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Upgrading of continuous black chrome plating line to process thin copper foil and to investigate electroforming of copper foil			
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31926-3-3036
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 12 21	COMPLETION DATE:	84 11 19
NEXT MILESTONE & DATE:	84 11 19		

CONTRACTOR: Solarsystems Industries Ltd. #2 - 11771 Horsehoe Way Richmond, B.C. V7A 4S5	PRINCIPAL INVESTIGATOR: E.W. Hoffmann (604) 271-2621
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $41 802	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to investigate potential solutions to the technological problems associated with plating metal foils in the 0.05 to 0.20 mm thickness range.

The existing plating machinery will be upgraded to allow plating of thin copper foil and methods for applying adhesive to the back of the copper foil will be investigated. A study will be conducted to determine the feasibility of constructing an electroforming machine to produce copper and nickel foil. This study will include the conceptual design of the plating chemistry, plating parameters, mechanical and electrical design, and effluent treatment.

KEY WORDS: Solar, collector, black chrome, electroforming, copper

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Stainless steel solar energy absorber technology and product development		
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31926-3-3038
STATUS: IN PROGRESS AS OF:			
CONTRACT START DATE:	83 12 19	COMPLETION DATE:	84 07 19
NEXT MILESTONE & DATE:	84 07 19		

CONTRACTOR: Sun Ray Solar Systems Limited 2429 Seminole Street Windsor, Ontario N8Y 1X2	PRINCIPAL INVESTIGATOR: E. Pattison (519) 253-1182
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $85 205	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Further work will be carried out on the development of stainless steel absorber plates with the ultimate aim of mass production. The use of stainless steel is proposed in an attempt to obtain longer solar collector lifetimes, reduced maintenance, the possibility of using a greater selection of heat transfer fluids, and lower initial costs compared to copper absorbers. This work follows on from contract no. 02SX.31155-0-2721I and will involve the design of a prototype absorber and preliminary design of the tooling. A cost analysis will be made on a domestic hot water package utilizing such an absorber. The prototype fabrication will follow the final design and production of the tooling.

KEY WORDS: Solar, DHW, Stainless steel, absorber

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of a nickel electroformed absorber and a NiS-ZnS selective surface for a liquid flat plate collector		
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31926-3-3044
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 12 16	COMPLETION DATE:	85 04 15
NEXT MILESTONE & DATE:	85 04 15		

CONTRACTOR: A.D. Plating and Electroforming 110 Aikman Avenue Hamilton, Ontario L8M 2K9	PRINCIPAL INVESTIGATOR: N. Dalacu (416) 523-4636
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $57 313	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The aim of this work is to develop low-cost, durable selectively coated absorbers for flat-plate solar collectors using electrodeposition techniques.

The electroforming processes were previously investigated (No. 081-035/1-2623) and the selective passivation and inflation technique has proven practical and shows promise of becoming cost effective. Under this contract a process for making an electroformed absorber of nickel and nickel alloys is to be designed along with a method for deposition of NiS-ZnS on electroformed substrates. The surface of the resulting absorber plate is then to be characterized and thermal performance and low-flow exposure tests carried out on the absorber in a standard solar collector box.

KEY WORDS: Solar, DHW, collector, absorber, nickel, electroform, selective surface

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: To research the thermal diode collector concept and to develop low and medium temperature solar heating systems based on that concept

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 02SX.31155-2-2617

STATUS: COMPLETED

CONTRACT START DATE: 82 06 23 COMPLETION DATE: 84 01 04

CONTRACTOR:
Norsun, a division of
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$145 707

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A thermosiphon freeze-protection system for thermal-diode solar collectors was designed, developed, and tested, as was a timer control device for single-tank SDHW systems. An attempt was made to design and develop a thermal-diode collector for low temperature applications such as swimming pools, but testing showed that the simple changes made to reduce cost affected performance more adversely than had been anticipated; that a better understanding of the boiling/condensing phenomenon is required in order to design such a collector; and that the changes needed are of a more fundamental nature.

The largest portion of the work was concerned with obtaining a basic understanding of the boiling/condensing process. The relevant literature on types of boiling, on modelling boiling events, on containment materials, and on working fluids was surveyed. A test rig having transparent glass boiling tubes was constructed in which parts of these tubes could be replaced by tubes of other materials. Various diameters of tubes were also investigated. Two main types of boiling were observed: "perking", higher frequency events occurring at higher inlet water temperatures; and "geysering", lower frequency events occurring at lower inlet water temperatures. The work continues in later contracts.

REPORTS AND REFERENCE SOURCES: A project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, collector, thermosiphon, controller, DHW, boiling, condensing

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of an improved solar domestic hot water system

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	04SX.31155-2-2624
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	82 07 16	COMPLETION DATE:	84 05 30
NEXT MILESTONE & DATE:	84 05 30		

CONTRACTOR:
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NRC PROJECT SCIENTIST:
K.A.H. Mills
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(613) 993-2730

CONTRACT PRICE:
$63 193

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A prototype solar domestic hot water (DHW) system using a side-arm thermosiphon heat exchanger is to be built and tested with the aims of optimizing control strategies, increasing performance, and lowering costs.

A test facility is to be setup to determine the baseline performance of a DHW system and the performance of the system with the addition of a thermosiphon heat exchanger, inlet diffusers, and various control strategies. Dye injection and visual observation will be used to evaluate different inlet diffusers. The effect of a side-arm tube-in-shell heat exchanger on system performance and storage tank thermal gradients will be determined. The best sensor location will be determined and an interactive auxiliary controller (Reltek Inc., DSS File n° 04SX.31155-0-2689E) will be used to maximize the energy collected and an optimum control algorithm will be established.

Discussions with manufacturers of the required components will be carried out and a prototype DHW system fabricated and tested.

KEY WORDS: Solar, DHW, thermosiphon, heat exchanger, controller

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of a two phase thermosiphon solar domestic hot water system		
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	05SX.31155-2-2642
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	82 12 13	COMPLETION DATE:	84 05 30
NEXT MILESTONE & DATE:	84 05 30		

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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$51 834

FUNDING AGENCY:
Solar Energy Program
National Research Council
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Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to develop an integral collector/storage thermosiphon solar DHW system based on the Nortec thermal diode concept.

Freeze protection, overtemperature protection, safety devices, and tank alternatives are to be investigated. A modified thermal diode collector with external heat exchanger suitable for fitting inside and integral storage tank is to be developed and a solar/auxiliary storage tank with appropriate openings, diffusers, etc. is to be designed. A prototype system will be fabricated and tested outdoors.

KEY WORDS: Solar, DHW, storage, thermosiphon

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a thermosiphon domestic hot water package

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	04SX.31155-2-2715
STATUS: IN PROGRESS AS OF:	84 04 20		
CONTRACT START DATE:	82 09 13	COMPLETION DATE:	84 06 30
NEXT MILESTONE & DATE:	84 06 30		

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CONTRACT PRICE:
$40 046

FUNDING AGENCY:
Solar Energy Program
National Research Council
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Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A thermosiphon domestic hot water (DHW) system including collectors, absorbers, and storage is to be designed and built in order to obtain the optimum system configuration.

Initially the absorber, mounting frame for the storage tanks, piping, and packaging are to be designed. Two storage tanks (180 and 270 L), four different sizes of collector enclosures, and fifteen absorbers using various header and riser sizes are to be constructed. The optimum system configuration will be determined by testing fourteen system combinations at various collector slopes and tank heights above the collector.

Prototype systems using the four optimal designs will then be built and performance tested.

KEY WORDS: Solar, DHW, thermosiphon

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design and construction of an improved solar domestic hot water system. Phase II	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31155-2-2735
STATUS: COMPLETED	
CONTRACT START DATE: 82 09 22	COMPLETION DATE: 83 09 01
CONTRACTOR: SolWay Solar Engineering Ltd. 30 - 942 S.W. Marine Drive Vancouver, B.C. V6P 5Z2	PRINCIPAL INVESTIGATOR: J.L. Richardson (604) 324-3327
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $48 863	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The work completes a two phase project to develop a packaged residential sized solar hot water system that combines the reliability of drainback freeze protection and the thermal efficiency of direct demand storage.

Pre-assembly of the pump, controller, and local piping on to a board that will fit into the small drainback vessel for shipping will reduce shipping costs and field labour. An expanding heat exchanger designed to fit through the electric element ports of a standard hot water tank also fits into the drainback vessel for shipping. Installation of the drainback vessel at an intermediate level closer to the solar collectors overcomes pumping head problems encountered in high systems.

The heat exchanger and complete system was tested at B.C. Research. The multi-tube heat exchanger proved to be very efficient but the result of the outdoor thermal performance test was inconclusive as there was no other system with which to make a direct comparison. The weather conditions over the seven days of testing were poor and the number of hours that the system was operating was not recorded. A test at the NRC test facility would be more useful.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A OS2. The full report contains details of the production process and is not available for distribution.

KEY WORDS: Solar, domestic hot water, heat exchanger, drainback

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of a refrigerant-charged solar DHW system

OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2741
STATUS: COMPLETED	
CONTRACT START DATE: 82 10 29	COMPLETION DATE: 84 02 24

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$49 444

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A first generation prototype of a solar domestic water heater, charged with refrigerant which is pumped round the solar loop, was designed, mathematically simulated, refined, built, and tested. The statement of work required thermosiphon freeze protection, but this was felt to be both unreliable, and wasteful of energy, and the system was completely redesigned so that only the refrigerant loop is exposed to ambient temperatures. A controller based on a microchip was designed to switch the pump on and off and to control the auxiliary heater according to the solar storage temperature and the time of day.

Measurements made on the system showed that it was producing the equivalent of 1.86 $GJ/m^2.a$ for a hot-water load of 225 L/d, not 2.2 $GJ/m^2.a$ as predicted by the simulation. Recommendations were made to use a more modern, more efficient solar collector; to replace the "thermal diode" dual tank with a single storage tank of the same size (360 L); to increase the amount of tank insulation; and to use a more appropriate circulating pump.

After making these changes, the contractor plans to market the solar heater.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A 0S2. The full report will be released in February 1985.

KEY WORDS: Solar, DHW, refrigerant

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of two solar domestic hot water systems based on the Amherst evacuated tube collector	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2743
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 11	COMPLETION DATE: 83 12 15
CONTRACTOR: Amherst Renewable Energies Ltd. 1070 Morrison Drive Nepean, Ontario K2H 8K7	PRINCIPAL INVESTIGATOR: Richard W. Davies (613) 820-3274
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: Karl A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $46 419	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

This report describes the design, development, and testing of freeze prevention and freeze damage protection concepts, and the subsequent development and testing of two prototype direct circulation solar domestic hot water systems.

A number of suitable pipe materials were identified that can repeatedly withstand the expansion forces of freezing water. These include CPVC and polybutylene plastic pipes as well as soft copper. On the other hand, a method of inserting a collapsible bladder made of Butyl rubber or soft silicone foam rubber inside conventional piping was also developed.

A variety of possible direct circulation system configurations were studied and the relative costs, performance penalties, and the various levels of freeze protection analyzed. A thermosiphon system and a pumped recirculation system were selected for development, and were tested over a thirty day interval.

Tests indicated that the two bladder materials provided protection against bokage due to freeze/thaw cycling but that plastic pipe fittings did not. Soft copper and CPVC provided only limited protection. The pumped recirculation freeze protected system was shown in tests to have a performance as well as price advantage over the thermosiphon system but the collector efficiency in the latter was higher. Long term testing of the freeze damage protection aspects is yet to be carried out. Further optimization of collector performance and identification of loss mechanisms would be beneficial.

REPORTS AND REFERENCE SOURCES: The full contract report and a project digest are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, DHW, evacuated tube

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a boiling/condensing solar DHW system. Phase I.	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31155-2-2744
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 83 01 28	COMPLETION DATE: 84 07 15
NEXT MILESTONE & DATE: 84 07 15	
CONTRACTOR: Lion Industries 6-1329 Niakwa Road Winnipeg, Manitoba, R2J 3T4	**PRINCIPAL INVESTIGATOR:** J.R. Lion (204) 257-7278
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	**NRC PROJECT SCIENTIST:** K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $50 669	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

An investigation of the use of a sub-atmospheric boiling/condensing water loop in a solar DHW system is to be carried out in order to determine the system characteristics and to evaluate its potential.

The initial step in this project will be the development of a computer program to simulate the phase change processes, fluid flow, and heat transfer within the system. A sequence of 24 days of weather conditions made up of pairs of days which produce the same daily average output as the months they simulate will then be created and the program will be used to determine the sensitivity of system performance to downcomer length and diameter and to heat exchanger surface area as well as to optimize the conceptual design.

The second stage will consist of construction and characterization of the basic system using simulated solar input to take the system through an abbreviated annual operating cycle.

KEY WORDS: Solar, domestic hot water, boiling/condensing

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Construction and testing of a prototype refrigerant-charged thermosiphon solar domestic hot water system	
OERD REFERENCE NO: 4.2.5	DSS FILE NO: 02SX.31155-2-2745
STATUS: COMPLETED	
CONTRACT START DATE: 82 10 29	COMPLETION DATE: 84 01 31
CONTRACTOR: Solartech Limited 39 Cranfield Road Toronto, Ontario M4B 3H6	PRINCIPAL INVESTIGATOR: Bernard Ennis (416) 752-4990
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: Karl A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $35 468	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The purpose of this work was to construct and test a prototype refrigerant-charged thermosiphon solar domestic hot water system having the collector and the storage tank as an integral unit. The design is based on the work performed under a contract entitled "Feasibility Study of a Refrigerant-Charged Thermosiphon Domestic Hot Water System" (DSS file number 04SX.31155-0-2689B).

Complete design drawings were produced, a prototype system built, and the system was tested, first by the contractor, and then by the Ontario Research Foundation (results to come). Single-day testing yielded a 55% efficiency, multi-day testing yielded a 45% efficiency. Winter efficiency is expected to be about 35%. Tests were made to verify the appropriateness of both the evaporator/condenser area ratio and the refrigerant charge level.

The contractor estimates that a system with a 3.5 m^2 absorber and a 180 L tank would supply 100% of the hot water requirements of a family of four or a typical summer day in Toronto. He suggests that this system is suitably sized for year-round use and could retail for about $1900. Recommendations for better testing and refinements to the system are made.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, DHW, thermosiphon, refrigerant

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of a bubble pump solar collector for solar domestic hot water systems - Phase I		
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31155-2-2746
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	82 12 21	COMPLETION DATE:	85 04 30
NEXT MILESTONE & DATE:	85 04 30		

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CONTRACT PRICE:
$146 711

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to further investigate the use of the solar bubble pump concept, to determine the optimum collector configuration, working fluid, and to size system components.

A review of previous experimental work will be undertaken and performance criteria setup for the comparison of collector properties such as fluid flow, heat required to start pumping action, etc. A working fluid is to be selected followed by optimization of collector parameters and empirical tests on a simple single pipe model.

The second stage of the work will involve (i) development of criteria and test methods for comparing the performance of various system configurations, (ii) determination of the optimum system design, and (iii) testing of a full scale system model using simulated heat inputs. This testing will include writing a computer program for control of indoor and outdoor testing, and comparison testing with a conventional DHW system using electric heat. The final report will include recommendations on a final bubble pump DHW system design.

KEY WORDS: Solar, DHW, bubble pump

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of a low-flow solar collector for domestic hot water	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2747
STATUS: COMPLETED	
CONTRACT START DATE: 82 12 22	COMPLETION DATE: 84 05 31
CONTRACTOR: Queen's University School of Graduate Studies & Research Kingston, Ontario K7L 3N6	PRINCIPAL INVESTIGATOR: C.K. Rush Dep. of Mechanical Engineering (613) 547-6949
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $37 178	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Solar water heating plants which use single tanks for storage and supply of hot water and which operate with temperature stratification offer attractive economic benefits. This report examines a number of means of achieving temperature stratification. These include: tank stratifiers designed to return heated water to the storage tank at the vertical level having about the same temperature as the returning water; parallel loops for water circulated to the collectors such that high flow passes through the thermal diode collector to achieve good heat transfer and low flow passes through the storage tank to avoid mixing; constant inlet temperature to the storage tank; and supply and return of the circulating water to the bottom of the storage tank with consequent avoidance of mixing with higher temperature water at higher levels in the tank.

The best arrangement to achieve tank temperature stratification and maximum collected energy under various solar conditions appears to be the Low Flow Bypass concept in which parallel loops are used to obtain high flow through the collector and low flow through the storage tank. The inlet and outlet flows to the collector are taken from the bottom region of the storage tank.

Only limited success was achieved with tank stratifiers designed to return heated water to the storage tank at the vertical level where the returning water temperature matched that at the vertical level.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Cnada Institute from Scientific and Thechnical Information (Energy Library), National Research Cjouncil, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Solar, DHW, low flow, thermal diode collector

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of heat-pipe solar domestic hot water systems - Phase I	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2748
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 11	COMPLETION DATE: 84 01 12
CONTRACTOR: Hawes and Wight Limited P.O. Box 821 Pointe Claire, Quebec H9R 4Z5	PRINCIPAL INVESTIGATOR: W. Wight (514) 848-7257
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $56 755	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The initial work was concerned with the appraisal of various methods of transferring heat downwards, including electrically driven pumps using both photovoltaic and utility power, and a number of self-pumped circulation concepts described in the literature. A mock-up of the downward-transfer heat pipe was constructed, and shown to convey heat at the rate of 800 W from the evaporator to the condenser 7 m below. The system requires no external controls and no external power except sunshine.

The efficiency was only about 45% due to a long recycle time, but there are obvious ways to reduce this. Being a vaporizing/condensing system, very efficient heat transfer is theoretically possible.

The concept envisages a factory-sealed unit, so the refrigeration trade will not be required for installation. The system is automatic, resistant to frost damage, and has little susceptibility to corrosion. A survey was performed to assess the potential market for such a system. Work continues under contract file no. 31926-4-5007.

REPORTS AND REFERENCE SOURCES: This project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. M-55, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, DHW, heat pipe

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Further development of solar domestic hot water systems

OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2860
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 03 23	COMPLETION DATE: 84 06 29
NEXT MILESTONE & DATE: 84 06 29	

CONTRACTOR: Solcan Limited R.R. #3 London, Ontario N6A 4B7	PRINCIPAL INVESTIGATOR: Robert K. Swartman (519) 473-0501
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $74 256	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

Improvements of Solcan's solar domestic hot water system are to be made with the aim of increasing the solar contribution while lowering the cost.

An integrated DHW/auxiliary storage tank which is compact and easily installed is to be designed and the use of improved materials and standard manufactured components investigated. An experimental tank with a temperature probe will be used to investigate the stratification and the effectiveness of the heat transfer process.

A comparison of draindown valves will be carried out to select a reliable and economical valve for cold weather operation. Solutions to the potential failure of vacuum breakers and automatic air vents will be investigated including the use of anti-icing materials and heated enclosures. This information will then be used to develop a reliable year-round draindown system for the Canadian climate.

An analysis of freeze-protection options for the Solcan thermosiphon system will be carried out including: manually assisted draining, fully automatic draining, and circulation of an antifreeze mixture through the collectors to an internal heat exchanger.

KEY WORDS: Solar, domestic hot water, DHW, thermosiphon, draindown

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Refinement of the Watershed tank in tank DHW storage system for commercial applications	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2863
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 83 04 14	COMPLETION DATE: 84 11 30
NEXT MILESTONE & DATE: 84 11 30	
CONTRACTOR: Watershed Energy Systems 97 Six Point Road Toronto, Ontario M8Z 2X3	PRINCIPAL INVESTIGATOR: Doug Hart (416) 233-3241
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Rd., Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Rd., Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $39 786	FUNDING AGENCY: Solar Energy Program, National Research Council, Bldg. R-92, Montreal Rd., Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to develop an improved tank-in-tank storage tank/heat exchanger for use in drainback residential or commercial solar hot water systems.

The work will include investigation of inner tank coatings to improve corrosion resistance, improvement of air tightness and redesign of pipe fittings for the outer tank, and development of a draining technique and improved support system for the inner tank. A prototype of the new storage system will be produced and working drawings developed.

KEY WORDS: Solar, storage, heat exchanger

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: An investigation of a solar domestic hot water system

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31926-3-0092
STATUS: IN PROGRESS AS OF:	84 04 03		
CONTRACT START DATE:	83 10 06	COMPLETION DATE:	84 08 09
NEXT MILESTONE & DATE:	84 08 09		

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CONTRACT PRICE:
$66 520

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

An investigation of ideas for increasing the cost-effectiveness of solar DHW system will be carried out following on from work done by Prof. K.G.T. Hollands while at NRC.

The work will involve both analytical and experimental explorations of means for reducing the copper content in solar collectors. A determination of the amount of insulation required will be made. A clear plastic model of the system will be constructed and used to evaluate new ideas. After designing the heat exchanger, and choosing the piping and pump, a collector will be manufactured and the full drainback system assembled and tested.

KEY WORDS: Solar, domestic hot water, cost-effectiveness, drainback

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Construct, test, and evaluate a heat exchanger for use in refrigerant-charged, thermosiphoning solar DHW heaters

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 04SX.31926-3-3009

STATUS: COMPLETED

CONTRACT START DATE: 83 09 09 COMPLETION DATE: 84 03 20

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$10 386

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT PRECIS:

A prototype double-thermosiphoning refrigerant-water (DTRW) heat exchanger was built, and with the addition of a solar collector, a tank, a pressure-activated valve and plumbing, was used for a solar domestic water heater. The design of the heat exchanger was aimed at, and generally succeeded in providing the following characteristics:

- large heat transfer area;
- small height;
- low resistance to flow on both sides;
- minimum heat loss from reverse thermosiphoning;
- over-temperature protection;
- built-in stagnation volume.

The heater based on this heat exchanger was tested and shown to be suitable for demands for hot water from 225 to 600 L/d. The performance of the system was also simulated mathematically. Both the heat-loss factor of the collector and the bypass flow through the heat exchanger had to be adjusted to conform to the empirical results, the first because of low flow, the second due to different flow/volume ratios. Annual projections could then be made. The solar contributions were projected at 2.26 $GJ/m^2.a$ for a load of 225 L/d and 3.24 $GJ/m^2.a$ for 600 L/d with a 180 L tank and a 4.74 m^2 collector area. With a 270 L tank solar contributions only 1.5% higher were predicted.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, domestic hot water, heat exchanger, refrigerant, thermosiphon

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: A new solar domestic hot water system

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	02SX.31926-3-3066
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	84 02 27	COMPLETION DATE:	84 09 21
NEXT MILESTONE & DATE:	84 09 21		

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$57 357

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this project is to develop a new SDHW system.

The system will use a thermosiphon type collector with collector mounted tank and heat exchanger. The company will develop freeze protection for the external piping using one of several novel mechanisms. These include using heat from the user's house transfered by means of a thermosiphon or heat pipe, or alternatively a tracer pipe to maintain flow at all times.

Watershed Energy Systems Ltd. will also develop the tank, heat exchanger, and preinsulated piping and will package and test the system.

KEY WORDS: Solar, DHW, freeze protection, thermosiphon

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of an integral collector storage based SDHW system

OERD REFERENCE NO:	4.2.1	DSS FILE NO:	05SR.31926-3-3067
STATUS: IN PROGRESS AS OF:	84 03 13		
CONTRACT START DATE:	84 03 13	COMPLETION DATE:	85 06 10
NEXT MILESTONE & DATE:	85 06 10		

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$49 381

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this project is to develop a solar domestic hot water (SDHW) system using the "integral collector storage" (ICS) principle. The system will have a measure of freeze protection thereby extending the market for the low cost system to mild freezing climates.

The work to be undertaken includes the determination of the optimum geometry of the ICS collector including aperture area to storage volume, locating the compressible materials and testing their effectiveness, and constructing a test stand in order to conduct side-by-side tests of this collector and a principal DHW system.

KEY WORDS: Solar, DHW, integral collector storage, batch heater, breadbox heater

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Research and development of a lower cost solar hot water system		
OERD REFERENCE NO:	4.2.1	DSS FILE NO:	05SR.31926-3-3068
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	84 03 21	COMPLETION DATE:	84 09 21
NEXT MILESTONE & DATE:	84 09 21		

CONTRACTOR: SolWay Energy Corporation 30-942 Southwest Marine Drive Vancouver, B.C. V6P 5Z2	PRINCIPAL INVESTIGATOR: J.L. Richardson (604) 324-3327
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $40 772	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A prototype integrated collector-storage solar domestic hot water system is to be designed and built.

Integrated collector-storage or "bread-box" units have good potential for cost-effectiveness in seasonal use or where freezing temperatures are rare. In this work the overall design of such a unit will be carried out including development of the storage tank, testing of various selective surfaces, and development of the glazing system and support structure. A prototype system suitable for testing will be constructed.

KEY WORDS: Solar, DHW, integrated, selective surface

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Computer simulations of solar domestic hot water systems

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 04SX.31155-1-2652

STATUS: COMPLETED

CONTRACT START DATE: 81 12 11 COMPLETION DATE: 83 09 30

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
B.E. Sibbitt
Solar Energy Program,
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Ottawa, Ontario, K1A 0R6
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CONTRACT PRICE:
$14 060

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Computer simulations were performed on eleven solar domestic hot water systems which were the first set of systems tested at the NRC SDHW test facility. The simulations were done to supply information on the anticipated performance limitations and on the specific monitoring requirements of the individual systems.

Modifications were made to WATSUN 3 DHWA simulation tool to account for the effect of stored water in load-side coil-in-tank heat exchangers on the performance of the system.

This contract was preparatory to contract no. 04SX.31155-2-2790.

These simulations indicated:

(1) Annual system efficiencies of about 35% or 1.9 GJ/m^2·a).
(2) Little sensitivity (2%) to year to year variations in the weather data (1971-1973).
(3) The importance of high effectiveness for load side heat exchangers.
(4) Pump energy contribution of as much as 18% to collector loop energy.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Solar, simulation, DHW, WATSUN

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Simulation of a single-pass low-flow solar domestic hot water system using SOLAR-C

OERD REFERENCE NO: 4.2.1 **DSS FILE NO:** 02SX.31155-2-2742

STATUS: COMPLETED

CONTRACT START DATE: 82 12 02 **COMPLETION DATE:** 83 11 30

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$40 679

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

It has been postulated that using a lower collector flow rate will preserve stratification in solar storage and therefore maximize the amount of energy delivered by the system. A single-pass low-flow solar DHW system was simulated using the SOLAR-C hybrid computer to investigate this postulate.

The initial stage of this work involved the conversion of the SOLAR-C program to the VAX computer at the National Research Council. A stratified tank module was added to SOLAR-C. Simulation experiments, including control strategy and weather variations were carried out and evaluated to determine the potential of the low-flow single-pass concept.

The study concludes that low-flow DHW systems should perform as well as conventional systems and that cost reductions may be realized by using smaller pumps, simpler controls, and redesigned collectors.

REPORTS AND REFERENCE SOURCES: The project digest and the full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A 0S2

KEY WORDS: Solar, DHW, SOLAR-C, low flow

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: A computer parametric study of thermosyphon SDHW systems

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 02SX.31926-3-0084

STATUS: COMPLETED

CONTRACT START DATE: 83 06 07 COMPLETION DATE: 83 10 15

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$16 380

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The SYPHON computer program was used to simulate four types of thermosyphon systems in Vancouver, Winnipeg and Ottawa. The four system types included:

(1) Standard (water-filled)
(2) Phase-change (refrigerant-filled collector loop)
(3) Antifreeze (glycol-filled collector loop)
(4) Hybrid (glycol-filled collector loop exchanging heat with a pumped potable water loop)

The study examined those design parameters that affect mass flow rate such as collector pressure drop, height of tank above collector, location of collector return to tank connection, and diameter of collector loop piping.

The study presents recommended design values for the parameters examined for each of the system types.

Collector pressure drops for twelve Canadian flat-plate collectors are also presented for a common flow rate of 1.0 $L/m^2 \cdot min$ and the average operating season for water-based thermosyphon systems is tabulated for eleven Canadian cities.

The study found that phase change and glycol systems saved the most energy and that the performance of the hybrid system (which exhibits greater flexibility for installation) was 15-20% less. The standard system performed well in Vancouver and poorly in Winnipeg, the result of operating season duration.

REPORTS AND REFERENCE SOURCES: Available as SEP Contract Report no. Sim-8 from Publication Sales & Distribution, National Research Council, Montreal Road, Bldg. R-88, Ottawa, Ont. K1A 0R6 or on loan from Canada Institute for Scientific and Technical Information (Energy Library).

KEY WORDS: Solar, SDHW, thermosyphon, design, simulation

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Modification and testing of WATSUN compatible tank-in-tank model	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31926-3-5046
STATUS: COMPLETED	
CONTRACT START DATE: 84 02 16	COMPLETION DATE: 84 03 19
CONTRACTOR: Sheaff and Associates Eng. Inc. P.O. Box 1048 Manotick, Ontario K0A 2N0	PRINCIPAL INVESTIGATOR: Nathan Sheaff (613) 692-3506
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: R. Wylie Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $5152	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

This report describes the work undertaken during the development and implementation of a mathematical model for load-side DHW tank-in-tank heat exchangers in the WATSUN computer program.

The model was developed based on standard heat transfer correlations, and was fully discussed with researchers at NRC and Waterloo prior to implementation and testing with a PDP-11/23 copy of the WATSUN 5.1 program.

This document serves both to report to the crown on the completion of the work; and to provide the WATSUN User Service with the necessary information to allow installation of the model on the Waterloo mainframe computer system.

Contents include a description of the assumptions used, derivation of the model, sample run inputs/outputs, a copy of the modified WATSUN source code, inserts for the WATSUN User Manual, and a list of variables used in the subroutines.

The model was developed with more emphasis placed on ensuring confidence rather than ease of computation (and hence computer cost). Rather than introduce assumptions that would lessen the confidence in the results, it was decided to develop a reasonably sophisticated model initially, with intent that simplifications may be introduced at future dates as experience permits.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, DHW, simulation, WATSUN, modelling, heat exchanger

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Installation and monitoring of 20 solar domestic hot water systems	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-0-2670
STATUS: IN PROGRESS AS OF: 84 03 31	
CONTRACT START DATE: 80 09 10	COMPLETION DATE: 86 01 31
NEXT MILESTONE & DATE: Quarterly monitoring reports	
CONTRACTOR: Institute of Man & Resources P.O. Box 2008, 50 Water Street Charlottetown, P.E.I. C1A 1A4	PRINCIPAL INVESTIGATOR: David M. Murray (902) 892-0361
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: B. Sibbitt Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $198 684	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The Institute of Man & Resources, Charlottetown, Prince Edward Island, supervised the installation of twenty solar domestic hot water heaters (DHW) on single family houses in one community. The objective of the work was to determine the installation costs of a representative solar DHW system using the learning curve of a single installation contractor. Secondary objectives were to determine the performance of the systems over a period of five years and to determine the impact of a solar system on hot water consumption.

The equipment used was the Solarsystems 830, a three panel drainback system. The report concludes that the Canadian Solar Industries Association trained installer had a shallow learning curve showing that competent heating and plumbing contractors should have no difficulty with simple solar domestic hot water systems after training. The average installation cost was $1388 and the delivered equipment cost was $1926 giving an average installed cost of $3300. No markup was included on the solar equipment. There is some potential for slight cost reductions to $3000 per system if installation activity is better scheduled.

Future reports will comment on technical and economic performance of the systems.

REPORTS AND REFERENCE SOURCES: Available as contract reports Instal-2, Parts 1 and 2 from Solar Energy Program Information Office, or on loan from the Canada Institute for Scientific and Technical Information, (Energy Library), National Research Council, Building M-55, Ottawa, Ontario, K1A 0S2

KEY WORDS: Solar, domestic hot water, field test, monitoring

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Prototype testing of a drainback solar domestic hot water system

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 04SX.31155-1-2606

STATUS: COMPLETED

CONTRACT START DATE: 81 04 06 COMPLETION DATE: 83 10 15

CONTRACTOR:
Watershed Energy Systems Ltd.
97 Six Points Rd.,
Etobicoke, Ontario
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$52 033

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A prototype drainback solar domestic hot water system was monitored over a two-year period using an Aeolian Kinetics D.A.S. with 40 input sensors and a 15-s sampling interval.

The parameters assessed included: collector working temperatures, efficiency, fin effectiveness, and humidity, outside temperature, solar radiation, piping losses, system C.O.P., storage losses, heat exchanger effectiveness, and overall energy balance. In addition, component tests were carried out on materials, specifically to evaluate the long-term effects of collector stagnation and evidence of corrosion on the tank-in-tank heat exchanger and pump.

The collector performance was shown to be better than NSTF data (likely due to mounting and site features) although the loss coefficient was higher than predicted. The 10-month stagnation period had no measureable effect on performance or weathering characteristics. The tank-in-tank heat exchanger demonstrated excellent thermal performance. However, substantial corrosion was evident on both the inner tank and the cast iron pump at the end of testing.

Recommendations for several improvements to the system resulted from this work. The system is to be produced commercially once the corrosion problem is solved and the system is upgraded.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, drainback, testing, corrosion, development, hot water

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Field-test program for prototype solar domestic hot-water systems	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-1-2637
STATUS: IN PROGRESS AS OF: 84 03 31	
CONTRACT START DATE: 81 07 07	COMPLETION DATE: 86 03 31
NEXT MILESTONE & DATE: Reports at six month intervals	
CONTRACTOR: Institute of Man & Resources 50 Water Street, Box 2008 Charlottetown, P.E.I. C1A 1A4	PRINCIPAL INVESTIGATOR: David M. Murray (902) 892-0361
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: B. Sibbitt Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $262 703	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

Prototype solar domestic hot-water systems are to be installed, field tested, and modified to improve performance.

Specific hot-water systems are to be procured and installed in private homes according to the manufacturers' instructions. The cost and ease of installation, data from cold water and kWh test meters, and the maintenance history of the systems are to be documented. The manufacturers are to be advised of the systems' operation, problems encountered, and proposed improvements. Any modifications made and the resulting changes in performance are to be recorded.

KEY WORDS: Solar domestic hot water, field test

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Installation and testing of a solar source heat pump domestic hot water system	
OERD REFERENCE NO:	4.2.1	DSS FILE NO: 07SX.31155-2-2730
STATUS: IN PROGRESS AS OF:	83 12 21	
CONTRACT START DATE:	82 08 09	COMPLETION DATE: 84 04 30
NEXT MILESTONE & DATE:	84 04 30	

CONTRACTOR: B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	PRINCIPAL INVESTIGATOR: M. Movassaghi (604) 224-4331
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: S. Harrison Division of Building Research National Research Council Ottawa, Ontario, K1A 0R6 (613) 993-1421
CONTRACT PRICE: $68 572	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this work is to determine the performance of a solar source heat pump domestic hot water (DHW) system for the purposes of concept evaluation, system optimization, development of a test procedure, and computer model validation.

The DHW system is to be purchased and installed at the B.C. Research Solar Development Test Facility. The monitoring equipment is to be installed and interfaced with the Facility's computer/data logger. After the system is commissioned it is to be monitored for 12 months by measurement of input electrical power, freon loop pressures and temperatures, water flows and temperatures, and by determination of the system's coefficient of performance and total contribution. The load volume and schedule to be used will be that defined by the CSA Standard F-379.

KEY WORDS: Solar, DHW, heat pump, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Evaluation and testing of refigerant charged solar domestic hot water systems	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31155-2-2751
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 82 10 29	COMPLETION DATE: 84 07 15
NEXT MILESTONE & DATE: 84 07 15	

CONTRACTOR: Ontario Hydro Research Division 800 Kipling Avenue Toronto, Ontario M8Z 5S4	PRINCIPAL INVESTIGATOR: Meyer Perlman (416) 231-4111
NRC PROJECT MANAGER: T.LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: B.E. Sibbitt Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $83 688	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The performance and reliability potential for active and passive refrigerent charged solar domestic hot water systems is to be determined.

Phase I of this project consisted of a survey of available systems and an evaluation of their potential for performance, reliability, and cost reduction.

Five refigerant systems will be tested in Phase II - three systems with thermosiphon refigerent loops & two with pumped refigerent loops. The systems were selected to cover the full range of available heat exchange and storage tank configurations.

The systems will be monitored for three months under variable climatic conditions, subject to an NRC derived hot water load schedule, and with an auxiliary set-point temperature adjusted to the lowest level at which the system just meets the CSA Standard F-379 drawdown test and delivery test requirements. The final report will show monitored performance and an analysis of possible component cost reductions.

KEY WORDS: Solar, DHW, refigerent, performance, cost reduction

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Basic monitoring and experimental work on the NRC solar domestic hot water system test facility	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 01SX.31155-2-2789
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 23	COMPLETION DATE: 84 05 03
CONTRACTOR: T.E.S. Limited 2548 Sheffield Road, Box 9372 Ottawa, Ontario K1G 3V1	PRINCIPAL INVESTIGATOR: D. Woods (613) 741-9402
NRC PROJECT MANAGER: T. Lefeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: B.E. Sibbitt Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $111 716	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The primary objective of this work was to provide the services necessary to conduct experiments in the NRC SDHW test facility leading to more cost-effective DHW system installations in the future. Daily monitoring of the solar DHW systems under test was carried out using integrating meters. These results were entered into an existing computer data base and 6-month system performance reports prepared. The work included maintenance and regular calibration of the pyranometers, flow meters, kWh meters, etc.

Experimental work included tests on:
collector arrays (3 panel); low collector flow rate and stratification; improved delta-T control; operation of interactive controllers; recirculation freeze protection; thermosyphon system; and various support activities, including design of an experimental solar storage tank for stratification tests; making two systems identical for sensitive evaluation of component changes; system installation removal, and modification; facility upgrading and operation of the HP85, D.A.S.

Results include:

(1) Instantaneous performance of three-panel conventional flat plate collector arrays is close to that measured for single collectors under standard test CSA F378.
(2) A high degree of stratification (more than 35°) has been observed in the storage tank of the thermosyphon system under test.
(3) Lowering collector-loop flow rates produced stratification in storage.
(4) Stratification disappears rapidly with some storage-heat exchanger combinations and is reasonably well preserved with others.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Solar, domestic hot water, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Analysis of solar domestic hot water system performance at the NRC test facility	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SX.31155-2-2790
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 03 21	COMPLETION DATE: 84 07 31
NEXT MILESTONE & DATE: 84 07 31	
CONTRACTOR: Enermodal Engineering Ltd. 421 King Street Waterloo, Ontario N2J 4E4	PRINCIPAL INVESTIGATOR: E.C. Shewen (416) 884-6421
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: B.E. Sibbitt Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $39 183	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The primary objective of this work is to identify high potential development areas for the next generation of improved cost performance solar DHW systems. The SDHW test facility monitoring accuracy and procedures are also to be assessed.

Data collected for 13 systems which have been tested at NRC's DHW test facility will be analyzed and the performance compared with simulated performance. The simulated performance of generic system types will be compared and a report prepared outlining recommendations and conclusions.

Background material for this contract was developed under contract no. 04SX.31155-1-2652.

The draft final report indicates that:

(1) The measurements of solar energy delivered and efficiency have uncertainties of $\pm$ 4%.
(2) The SDHW systems generally proved to be very reliable.
(3) More detailed monitoring should be implemented.
(4) Simulations agreed well with measurement for 8 of 12 systems simulated (poor collector characterisation is believed responsible for at least 3 of the cases which did not agree).
(5) Solar storage heat loss appears to be substantial (7-24% of storage input).
(6) Low capacitance load-side heat exchanger systems sensitive to load profile.
(7) The average collector operating point is about 0.07 $^{\circ}C \cdot m^2/W$.

KEY WORDS: Solar, DHW, systems, analysis, NRC test facility

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: WATSUN simulation of performance of solar domestic hot water systems versus collector flowrate

OERD REFERENCE NO: 4.2.1 **DSS FILE NO:** 04SX.31155-2-2868

STATUS: COMPLETED

CONTRACT START DATE: 83 03 31 **COMPLETION DATE:** 83 11 30

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CONTRACT PRICE:
$6987

FUNDING AGENCY:
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PROJECT PRECIS:

The effectiveness of several stratification-enhancing control strategies on the performance of a liquid-based solar system was assessed by performing year-long computer simulations using a modified version of WATSUN.

The reference system selected for the study was a two-tank domestic hot water system. Four different control strategies were analysed, in addition to a conventional ΔT controller. These were:

i) selecting a constant, but reduced, collector mass flow rate;
ii) utilizing the temperature at the top of the solar storage tank (rather than the bottom) for differential temperature control;
iii) adjusting the flow rate each month, by a factor inversely proportional to average daily collection time;
iv) continually adjusting the mass flow rate to ensure that the temperature of the fluid returning to the solar storage tank exceeded a preset value.

The simulation of these control strategies required modifications to several WATSUN models, including collector, controller, heat exchanger, and pump models.

A review of the results produced the following conclusions:

i) solar storage tank stratification has the potential to increase the solar fraction on the order of 15 to 20%;
ii) the lower flow rates used to improve stratification reduced collector performance offsetting any stratification-related improvements;
iii) the alternatives considered did not offer a distinct performance advantage over the conventional system.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, hot water, controls, flow rate, simulation, WATSUN

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Study, evaluation and monitoring of a low cost collector for domestic hot water systems	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 02SX.31926-3-0013
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 04 01	COMPLETION DATE: 84 06 30
NEXT MILESTONE & DATE: 84 06 30	
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CONTRACT PRICE: $15 430	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

An investigation to develop cost effective, simple, reliable solar collectors suitable for high production rates and capable of being successfully installed by a high proportion of home owners is to be carried out. A parallel study (contract no. 02SX.31926-3-0063) is evaluating the remainder of the system.

An evaluation of appropriate materials, design parameters, and production methods will be performed for a liquid collector suited for continuous strip production.

Full cost and performance figures are to be determined in the course of the work, and an assessment of the usefulness of further work on the collector will be made.

KEY WORDS: Solar, DHW, manufacture, collector

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Study, evaluation, and monitoring of a low-cost DHW system

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 02SX.31926-3-0063

STATUS: IN PROGRESS AS OF: 84 04 30

CONTRACT START DATE: 83 05 02 COMPLETION DATE: 84 05 30

NEXT MILESTONE & DATE: 84 05 30

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CONTRACT PRICE:
$10 481

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT OBJECTIVE AND DESCRIPTION:

An investigation to develop cost-efffective, simple reliable solar DHW systems suitable for high production rates and capable of being successfully installed by a high proportion of home owners is to be carried out. A parallel study (contract no. 02SX.31926-3-0013) is evaluating collectors for use in this system.

A thermosiphon collector with a small capacity header tank is to be evaluated. This collector is intermittently charged with cold water from a standard DHW tank or a side arm heat exchanger using a small circulator and small bore connecting pipe.

Full cost and performance figures are to be determined in the course of the work and an assessment of further work on the DHW system will be made.

KEY WORDS: Solar, DHW, thermosiphon

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Experimental evaluation of solar domestic hot water system test procedures	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 05SX.31155-2-2791
STATUS: COMPLETED	
CONTRACT START DATE: 82 07 01	COMPLETION DATE: 83 10 31
CONTRACTOR: Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario L5K 1B3	PRINCIPAL INVESTIGATOR: H. Pullan (416) 822-4111
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: R. Peters & P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $248 283	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this project was to experimentally evaluate the tests included in CSA Standard F379.1-M "Solar Domestic Hot Water Systems (Liquid-to-Liquid Heat Tansfer)". In particular, a comparison was conducted using the three methods of simulating the solar energy input to the SDHW system during a thermal performance test (using a solar radiation simulator, an electrical heater, or a combination of the two). Three SDHW systems were tested using each of the three techniques and the results analysed. A fourth SDHW system was tested at each of the three allowed draw volumes (150, 225, and 300 L/d) to determine the variation of performance with load.

In addition, an investigation of the applicability of the thermal performance tests to thermosyphon systems, including a test of one such system, was undertaken.

All five SDHW systems were also subjected to various functional tests included in the Standard, and recommendations for modifying the tests were made where applicable.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, domestic hot water, DHW, test, standard

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Construction of a solar domestic hot water test station for the National Solar Test Facility - Phase 1.	
OERD REFERENCE NO: 4.2.1	DSS FILE NO: 04SR.31926-3-3046
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 84 09 03	COMPLETION DATE: 84 12 31
NEXT MILESTONE & DATE: 84 12 31	
CONTRACTOR: Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario L5K 1B3	PRINCIPAL INVESTIGATOR: H. Pullan (416) 822-4111
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: S. Harrison & P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $131 276	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The National Solar Test Facility (NSTF) was originally built for NRC to conduct thermal performance tests on solar collectors, using an indoor solar simulator in accordance with established national standards. There now exists a recognized need for similar tests to be performed on complete, pre-packaged solar domestic hot water (SDHW) systems.

This project covers the first phase of a two-phase program, and deals with:

i) the development of performance tests for packaged solar domestic hot water systems.

ii) the construction and commissioning of the basic equipment required by the National Solar Test Facility to undertake such tests on a routine basis with acceptable standards of accuracy.

The proposed project covers work which is intended to complete approximately one-half of the outstanding tasks that are required to equip the NSTF to enable routine testing and certification of SDHW systems in accordance with CSA Standard F-379-M1982. Included are: upgrading existing SDHW test equipment to meet NSTF standards; updating the control and data acquisition system software; implementing a data analysis and an automated report generation system; and providing staff training and documentation.

KEY WORDS: Solar, domestic hot water, test, NSTF, DHW

PASSIVE

SECTION B

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NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Potential of passive solar strategies for office buildings	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31155-2-2702
STATUS: COMPLETED	
CONTRACT START DATE: 82 11 19	COMPLETION DATE: 83 12 30
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NRC PROJECT MANAGER: M. Glover Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $30 320	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Potential of passive solar strategies for office buildings.

The objectives of this study were to determine the potential for reducing energy use in office buildings by the adoption of passive solar strategies and to identify and evaluate the potential of new technologies that could be developed. The study involved modelling various building configurations and passive strategies for an office building located in Ottawa using the DOE-2 energy analysis program.

The intent of the study has been to evaluate the theoretical potential of the various passive options (such as daylighting, increasing south glazing, solar shading, and insulated shutters) to determine whether a particular option has a potentially worthwhile benefit before trying to solve any associated practical problems.

The main conclusions reached during this study are:

- south facing glass has the potential for reducing energy consumption if there is complete thermal mixing and shading is used to minimize unwanted solar gains;
- "Switchable" glazings are a particularly attractive technology to pursue;
- minimum envelope, deep-plan office buildings are not the most energy-efficient solution;
- the addition of an atrium increases energy consumption although an additional semi-heated amenity area is provided.

REPORTS AND REFERENCE SOURCES: This report is available as contract report no. Passive-7 from Publication, Sales & Distribution, National Research Council, Montreal Road, Building R-88, Ottawa, Ontario, K1A 0R6 or on loan from CISTI.

KEY WORDS: Passive, solar, daylight, cooling, natural ventilation, office buildings, windows, DOE-2

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Resource data requirements for daylighting and solar lighting design methods	
OERD REFERENCE NO: 4.2.2.	DSS FILE NO: 02SX.31155-2-2712
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 11	COMPLETION DATE: 84 02 29
CONTRACTOR: Ernest Wotton Consultants 78 Earl Gray Road Toronto, Ontario M4J 3L5	PRINCIPAL INVESTIGATOR: Ernest Wotton (416) 536-2075
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $15 500	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

This study reviews daylighting and solar lighting design methods and identifies the illumination and weather data required as input to these methods. The existing quality and availability of the required resource data for major Canadian cities is assessed and where the present data are lacking or unsuitable, recommendations are made for the acquisition of additional data or modifications to the present data. Experimental facilities for daylighting studies are identified and recommendations for additional facilities are made.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Buildin R-105, Ottawa, Ontario K1A OS2

KEY WORDS: Solar, passive, daylighting, solar lighting, resource data, design methods

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Computer simulation of enhanced direct gain passive solar heating systems	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 07SX.31155-2-2796
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 11	COMPLETION DATE: 83 07 11
CONTRACTOR: Enermodal Engineering Ltd. 421 King Street N. Waterloo, Ontario N2J 4E4	PRINCIPAL INVESTIGATOR: S. Carpenter (519) 884-6421
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $28 555	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT PRECTS:

This study analysed alternative ways of improving the performance of direct gain passive solar heating systems. The thermal performance of the different options under study was analysed using the Enerpass computer program. The base was a detached, single family house in Ottawa, incorporating high levels of insulation and tight building construction. The options analysed were: super-windows, phase change heat storage within drywall, domestic hot water (DHW) heat pump, use of off-peak power, glazing with switchable solar transmission, and forced ventilation systems. The study showed that super-windows increase passive solar contribution by up to 30%. With super-windows, there is problem of winter over heating and this can be effectively reduced through phase change materials in drywall, DHW heat pumps, or a combination of the two strategies. The issue of summer cooling was not addressed in the study.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2. See also: "Examination of several methods of improving the performance of direct gain passive solar heating systems" by S.C. Carpenter and M.S. Chamberlain. Paper no. PS1. 9th Annual Conference, Windsor, Ont. Aug. 1-5, 1983. Published by the Solar Energy Society of Canada Inc. Winnipeg. 1983.

KEY WORDS:Computer simulation, passive, solar, direct gain

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design: warehouse and light industrial buildings	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31926-3-0054
STATUS: IN PROGRESS AS OF: 84 01 03	
CONTRACT START DATE: 83 08 25	COMPLETION DATE: 84 05 30
NEXT MILESTONE & DATE: 84 05 30	

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CONTRACT PRICE: $32 405	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The study has three sub-objectives:

1) To create a short list of passive solar design strategies to be further developed and incorporated into future building projects;
2) To quantify the cost and performance of integrated passive solar design for warehouse and light industrial buildings;
3) To identify potential viable opportunities for product development. The analysis will be carried out using the DOE.2.1B program.

KEY WORDS: Solar, passive, design, integrated, industrial, daylighting

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design studies for low-rise retail buildings	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31926-3-0055
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 06 08	COMPLETION DATE: 84 07 01
NEXT MILESTONE & DATE: 84 07 01	
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CONTRACT PRICE: $39 243	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

An analysis of passive solar design strategies is to be carried out for low-rise retail buildings. This analysis will be carried out using the BLAST program with the daylight component calculated separately. From this a short list of promising design strategies which should be further developed and incorporated into future building projects is to be drawn up. The cost and performance of integrated passive solar design features for different types of retail buildings are to be quantified and the potential viable options for product development identified.

KEY WORDS: Solar, passive, integrated strategies, BLAST, daylighting

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design: institutional buildings

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	04SX.31926-3-0056
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 08 19	COMPLETION DATE:	84 07 10
NEXT MILESTONE & DATE:	84 07 10		

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CONTRACT PRICE:
$33 800

FUNDING AGENCY:
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PROJECT OBJECTIVE AND DESCRIPTION:

The study has three sub-objectives:

1) To create a short list of passive solar design strategies to be further developed and incorporated into future building projects;
2) To quantify the cost and performance of integrated passive solar design for different types of institutional buildings;
3) To identify potential viable opportunities for product development. The analysis will be carried out using the DOE.2.1B program.

KEY WORDS: Solar, passive, design, integrated, institutional, daylighting

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design: medium high rise housing

OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31926-3-0057
STATUS: IN PROGRESS AS OF: 84 01 03	
CONTRACT START DATE: 83 07 28	COMPLETION DATE: 84 07 10
NEXT MILESTONE & DATE: 84 07 10	

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CONTRACT PRICE:
$39 745

FUNDING AGENCY:
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PROJECT OBJECTIVE AND DESCRIPTION:

The study has three sub-objectives:

1) To create a short list of passive solar design strategies to be further developed and incorporated into future building projects;
2) To quantify the cost and performance of integrated passive solar design for medium/high rise housing;
3) To identify potential viable opportunities for product development. The analysis will be carried out using the DOE.2.1B program.

KEY WORDS: Solar, passive, design, integrated, high rise, daylighting

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Natural ventilation systems for passive cooling

OERD REFERENCE NO: 4.2.2	DSS FILE NO: 20SU.31926-3-0082
STATUS: COMPLETED 83 08 30	
CONTRACT START DATE: 83 06 02	COMPLETION DATE: 83 11 01

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CONTRACT PRICE:
$24 470

FUNDING AGENCY:
Solar Energy Program,
National Research Council
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Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The theoretical and experimental research carried out since 1950 on natural ventilation for passive cooling of buildings is reviewed. Most of the research deals with buildings in hot and humid regions of the world where air motion relative to the human body plays an important role in thermal comfort.

The natural ventilation research at the Florida Solar Energy Center is highlighted. This work includes the monitoring of test rooms, and the wind tunnel and outdoor testing of scale models. The outdoor testing of a scale model involves laser-smoke flow visualization and video recording during the night as well as air velocity measurements. FSEC has also experimentally validated the natural airflow equation and has suggested empirical values for the convection heat transfer coefficient for the walls in naturally ventilated rooms.

Natural ventilation can be employed for passive cooling of buildings in Canada in several ways. Ceiling (or table) fans are recommended to produce thermal comfort at higher temperatures. Cool night air should be circulated by opening windows, thereby creating cross ventilation, by a whole house fan or an air handling unit. The use of ceiling fans increases the heat transfer coefficient and the rate of coolness which may be stored in (or retrieved from) the building mass.

REPORTS AND REFERENCE SOURCES: This report is available as SEP contract report No. Passive-9 from Publication Sales & Distribution Office, National Research Council, Bldg. M-58, Montreal Road, Ottawa, Ontario, K1A OR6 or on loan from the Canada Institute for Scientific and Technical Information (Energy Library).

KEY WORDS: Solar, passive, cooling, performance monitoring, simulation

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Analysis of passive cooling options for low-energy housing

OERD REFERENCE NO: 4.2.2	DSS FILE NO: 24ST.31926-3-0100
STATUS: IN PROGRESS AS OF: 84 01 03	
CONTRACT START DATE: 83 10 13	COMPLETION DATE: 84 07 03
NEXT MILESTONE & DATE: 84 07 03	

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CONTRACT PRICE:
$55 280

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT OBJECTIVE AND DESCRIPTION:

Overheating appears to be a major concern for super-insulated houses incorporating large areas of low heat loss windows. The objective of this study is to analyse alternative passive solar and hybrid ventilation/cooling systems for low-energy buildings. The work will involve analysing the different options using the Thermal Analysis Residential Program (TARP).

KEY WORDS: Solar, passive, cooling, ventilation, simulation programs

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Cost analysis and guidelines for SEP Passive Solar Commercial Buildings Study	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31155-2-2614
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 82 05 31	COMPLETION DATE: 85 03 28
NEXT MILESTONE & DATE: 85 03 28	
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CONTRACT PRICE: $13 000	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The project objective is to develop cost guidelines for the SEP Passive Solar Commercial Buildings Study.

The guidelines will ensure that the cost data developed for the different projects will be presented in a consistent format and allow easy comparison between the different projects. The contractor will review and check the cost data submitted for the individual projects. A life cycle cost analysis will be carried out for each project. On the basis of the SEP project, preliminary conclusions and recommendations will be made on the cost effectiveness of passive solar systems for commercial buildings.

KEY WORDS: Passive, solar, commercial buildings, cost estimates, energy conservation, life cycle cost analysis

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design study of DHW heat pumps in passive solar houses

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 05SX.31155-2-2705

STATUS: COMPLETED

CONTRACT START DATE: 83 02 25 **COMPLETION DATE:** 84 03 30

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CONTRACT PRICE:
$22 459

FUNDING AGENCY:
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PROJECT PRECIS:

To help assess the potential of domestic hot water (DHW) heat pumps for low-energy housing, a design study was carried out for the Walker house located near Ottawa. The house incorporates a highly insulated, air tight building envelope. There is an insulated crawl space in the basement which acts as a pressurized plenum for distribution of circulated air. All heat gains are collected by the circulating air and delivered to the crawl space.

Detailed annual computer simulations were performed with the Enerpass program for conventional and heat pump DHW heating. The simpler monthly analysis tool, Hotcan was used for another 52 simulations. Variables included solar aperture area, location, heat loss factor, thermal mass, and DHW use.

The total estimated energy savings per year for the DHW heat pump are 67 GJ for space cooling. If the electrical cost is 4.5¢/kWh the annual cost savings is $125 or a simple payback of 8 years.

It is planned that the performance of the DHW heat pump installed at the Walker house will be monitored during the 84/85 heating season.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2.

KEY WORDS: DHW heat pumps, passive, solar, low-energy, domestic hot water

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Passive solar commercial buildings study	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31155-2-2764
STATUS: COMPLETED	
CONTRACT START DATE: 82 09 30	COMPLETION DATE: 83 07 28
CONTRACTOR: Novametric Engineering Inc. P.O. Box 8163 Saskatoon, Saskatchewan S7K 6C4	PRINCIPAL INVESTIGATOR: Allan R. Bens (306) 242-1185
NRC PROJECT MANAGER: Michael Glover Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: Michael Glover Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $18 805	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The design study involved a detailed cost and energy analysis for a new low-rise commercial structure to be located in Saskatoon. The proposed design incorporates additional south-facing window with overhang and increased thermal mass. Energy conservation features normally associated with low-energy housing are incorporated into the design including extra insulation, tight vapour/air barrier, and an air-to-air heat exchanger. The cost of including the additional features was estimated to be $16 000 (approx. 10% increase in capital cost) the energy savings generated about $2500 per year (approx. 30% of energy costs).

REPORTS AND REFERENCE SOURCES: The final report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Passive solar, commercial buildings, energy analysis

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Project sheets for Level B monitored buildings	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 07SX.31155-2-2798
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 03 16	COMPLETION DATE: 84 06 30
NEXT MILESTONE & DATE: 84 06 30	
CONTRACTOR: Low Energy Building Assoc. of Canada 53 Queen Street, Suite 22 Ottawa, Ontario, K1P 5C5	PRINCIPAL INVESTIGATOR: Linda Newell (613) 233-4179
NRC PROJECT MANAGER: J. Rollefson Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $13 668	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

Although the NRC Solar Energy Program has been involved in monitoring a number of projects, the results of this work have not been made available to building designers and contractors in a convenient published form. The objective of this study is to prepare a standard reporting format and then produce, in camera-ready form, a maximum of six project sheets.

KEY WORDS: Passive, solar, low-energy building

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design study for condominium apartment building

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 02SX.31926-3-0041

STATUS: COMPLETED

CONTRACT START DATE: 83 05 25 **COMPLETION DATE:** 84 01 06

CONTRACTOR:
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CONTRACT PRICE:
$15 449

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
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PROJECT PRECIS:

The purpose of the study was to analyze alternative passive solar, low-energy strategies for a proposed apartment building in Toronto. The building energy performance was studied using the Meriwether program, Enerpass program, and Sumac Target program. Based on the energy and cost analysis, the following conclusions were made. Although triple glazing is more expensive than double, total costs are less as there is no need for radiators under the windows. Heat loss from the building is also reduced. Glazing in the outside balconies cannot be justified in terms of energy savings alone although sunspaces will be included because of their market appeal. Other passive solar features which showed positive energy savings include reduced east/west windows and exterior shading. To transfer the passive solar gains from south to north, a California heat pump cycle was recommended. The system is cost effective in combination with other energy conservation options, including domestic hot water preheat, pool heating, exhaust air heat recovery, and thermal storage for off-peak power. Other recommended measures are a two speed ventilation system for cooling by outside air, a canopy over the underground parking access instead of ramp heating, and no garage heating.

The final predicted energy use is about one-third of comparable, recently constructed condominiums in the Toronto area.

REPORTS AND REFERENCE SOURCES: This report is available as contract report No. Passive 11 from Publications Sales & Distribution, National Research Council, Bldg. R-88, Montreal Road, Ottawa, Ontario, K1A OR6 or on loan from the Canada Institute for Scientific and Technical Information (Energy Library)

KEY WORDS: Passive, solar, apartment buildings, heat pumps, conservation

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design: athletics centre

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 04SX.31926-3-0058

STATUS: IN PROGRESS AS OF: 84 01 03

CONTRACT START DATE: 83 08 17 COMPLETION DATE: 84 07 10

NEXT MILESTONE & DATE: 84 07 10

CONTRACTOR:
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CONTRACT PRICE:
$41 700

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The purpose of this project is to carry out a detailed energy analysis and design study for an athletics facility located in Montreal. Various passive solar and daylighting features will be evaluated and detailed cost and performance estimates prepared.

KEY WORDS: Solar, passive, design, integrated, daylighting

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Preparation of passive solar design primer

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	04SX.31926-3-0064
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 10 26	COMPLETION DATE:	84 09 31
NEXT MILESTONE & DATE:	84 09 31		

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CONTRACT PRICE:
$24 930

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
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PROJECT OBJECTIVE AND DESCRIPTION:

A primer for the design of passive solar buildings is to be prepared.

The topics to be treated include: descriptions of the most common and appropriate passive solar and energy conservation techniques; guidelines for design of passive and hybrid systems; description of simulation tools; construction guidelines; and performance results.

KEY WORDS: Solar, passive, design, manual

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design and development of integrated passive solar systems

OERD REFERENCE NO: 4.2.2	**DSS FILE NO:** 04SX.31926-3-5023
STATUS: COMPLETED	
CONTRACT START DATE: 83 09 30	**COMPLETION DATE:** 84 03 30
CONTRACTOR: Hambro International Ltd. 215 Colonade Road Ottawa, Ontario K2E 7K3	**PRINCIPAL INVESTIGATOR:** E. Butts (613) 226-1074
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224	**NRC PROJECT SCIENTIST:** D. Colley Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $33 961	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The objective of the project was to develop a rational passive solar townhouse from both operating and cost viewpoints. The study was based on simulating the characteristics of the building design to predict energy and comfort performance.

The final report describes the process used to design a seven unit block of rowhouses so that they could take maximum advantage of a composite steel-joist/concrete-slab floor system used as a storage medium for passive solar energy. The passive solar rowhouse block was based upon a standard design built by Mastercraft Construction Corporation Limited. The report focuses upon the analysis and subsequent modelling results of the design. The building itself is described first, with an explanation of how the particular design was developed, the simulation methods used to analyze energy flows are briefly described, and the simulation results which cover the key concerns regarding energy performance and occupant comfort are given. Analysis and discussion of the modelling results leads into a concluding section on follow up monitoring.

The study concludes that up to 25% annual energy savings over the base case unit can be achieved by using the composite steel/concrete floor system and selected passive solar features. This result is to be confirmed through energy performance monitoring under DSS Contract No. 4-3024.

REPORTS AND REFERENCE SOURCES: Project digest and full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, passive, integrated design, residential

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Integrated passive solar design of the NRC Science Place Canada building, Winnipeg		
OERD REFERENCE NO:	4.2.2	DSS FILE NO:	04SX.31926-3-5033
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	84 01 17	COMPLETION DATE:	84 05 30
NEXT MILESTONE & DATE:	84 05 30		

CONTRACTOR:	PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:	**NRC PROJECT SCIENTIST:**
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CONTRACT PRICE:	**FUNDING AGENCY:**
$38 310	Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The energy and daylighting performance of the Science Place Canada Complex and integrated atrium are to be modelled and optimized.

The DOE-2.1B building energy analysis computer program will be used to model such parameters as percentage of glazing, roof line, thermal mass, integration with heating, ventilating, and air conditioning systems, lighting, solar thermal contribution, etc. The design of the atrium will be optimized using this program and feedback will be provided to the designers of the building so that viable features/changes may be incorporated into the atrium.

KEY WORDS: Solar, passive, integrated design, atrium

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Integrated passive solar design of a commercial retail building and community center in Merritt, B.C.	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31926-3-5034
STATUS: IN PROGRESS AS OF: 84 01 31	
CONTRACT START DATE: 83 12 07	COMPLETION DATE: 84 05 30
NEXT MILESTONE & DATE: 84 05 30	
CONTRACTOR: Solar Applications & Research Ltd. 3683 West 4th Avenue Vancouver, B.C. V6R 1P5	**PRINCIPAL INVESTIGATOR:** Ken Cooper (604) 733-5631
NRC PROJECT MANAGER: Michael Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224	**NRC PROJECT SCIENTIST:** Doug Colley Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $29 685	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

An integrated passive solar system is to be designed for a small retail and community center complex.

Both thermal performance and daylighting design will be addressed for this building which has an area of 465 m^2. Following a site analysis, thermal energy simulations will be carried out. A physical model will be constructed in order to assess the daylighting design. The daylighting will also be simulated using the "Microlite" program. The design documentation will also include a comparison of the incremental energy/cost budgets for the various passive features. This contract is scheduled such that the design details can be incorporated into the final construction plans.

KEY WORDS: Solar, passive, integrated design, retail building

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Window frame design for thick airspace windows

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 02SX.31155-2-2753

STATUS: COMPLETED

CONTRACT START DATE: 83 02 28 COMPLETION DATE: 84 03 15

CONTRACTOR:
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CONTRACT PRICE:
$48 698

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

Because of increased structural loads due to the heavier super-window glazing panels, window frames can no longer be fabricated from the more economical, smaller cross section sizes of wood. The objective of the study was to develop an operable window frame system based on wood or wood/hybrid construction.

The option of wood-waste, resin-bonded sections was evaluated but rejected because of low thermal conductivity and poor structural and screw holding properties. To improve the structural properties of softwood sections, the use of monomer/polymer resins was evaluated. By super-drying the wood, a consistent saturation of the wood was achieved. However, while the structural rigidity was improved, the thermal conductivity of the wood was increased and further work in this area was abandoned. The final design incorporated a rigid, multi-chambered PVC sash profile with reinforcing wood inserts. The PVC sash profile incorporated a separate isolated outer chamber fed from the drainage recess under the sealed edges of the insulating glass panel. This arrangement allows moisture to drain off through the bottom openings outisde of the primary bulb seal. The wood sill and frame were coated using an alkyd/isocyanate vapour cure system.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A OS2.

KEY WORDS:Window frames, super windows, passive, solar

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of rigid foam shutter and automatic activator system	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 02SX.31155-2-2754
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 02	COMPLETION DATE: 83 10 01
CONTRACTOR: Solsearch Ltd. P.O. Box 1869 Charlottetown, P.E.I. C1A 7N5	PRINCIPAL INVESTIGATOR: O. Hammarlund (902) 892-9898
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $48 395	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The project objective was to develop an RSI 1.76 (R10), automatic or semi-automatic insulated shutter which could be used in combination with standard windows for thick wall, super-insulated construction. Three operating systems were evaluated:

i) a semi-automatic shutter only closing automatically;
ii) a fully automatic shutter driven by a heat sensitive gas cylinder, and
iii) a fully automatic electrically operated shutter.

The study concluded that the third option which uses a very small electric motor to close the shutter, opening again by gravity was the most cost effective solution. The shutter can be controlled by a central photo cell on a programmed timer. During the day the shutter is stored within the thick wall space below. A working mock-up was tested for 2500 cycles or the equivalent of over 10 years of operation. The cost of producing a shutter of a 1 m^2 size would be about $90 FOB factory or about $120 installed. This cost does not include any framing modifications necessary nor the interior glazing. The system could be manufactured by a small regional company although a minimum 1000 units per year would be needed for a break-even operation.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Shutters, super windows, solar, passive

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of a multi-layer thin glass window

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 02SX.31155-2-2755

STATUS: COMPLETED

CONTRACT START DATE: 83 01 31 **COMPLETION DATE:** 84 04 30

CONTRACTOR:
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CONTRACT PRICE:
$84 994

FUNDING AGENCY:
Solar Energy Program
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Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of the study was to develop a super window consisting of multi-layers of thin fusion glass, inert gas fill, low-emittance coatings, and insulated glass edge seal.

The first phase of the study involved three tasks: preliminary design of edge seal; measurement and testing of material samples, and thermal and economic analysis of multi-layer glazing systems. Alternative edge seal designs are evaluated and the problem of barometric pressure glass breakage is reviewed. It is recommended that a moveable inner layer glazing design incorporating impermeable aluminum membrane seals be further developed. The solar beam transmittance and R-value measurements are listed for the different types of glazing materials and systems. Based on the thermal analysis, the following conclusions can be made:

i) at least three glazings are required to achieve the target U-value of 1.0 W/m^2 K;
ii) the use of a non-air fill gas can significantly reduce the U-value;
iii) the optimum inter pane spacing for double, triple and quad glazed windows is 12.5, 15, and 17.5 mm respectively;
iv) heat reflecting coatings should be placed on the warm side of a cavity and applied starting with the warmest cavity; and
v) the use of conventional float glass decreases the shading coefficient by 10-15% compared to low-iron borosilicate glass while the use of anti-reflective, low iron borosilicate glass increases the shading coefficient by a similar magnitude.

The cost analysis shows that with respect to average payback period the triple glazed, argon filled, single or double coated windows are the most cost effective although the analysis is very sensitive on the cost assumptions made for the borosilicate glass.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Borosilicate glass, super windows, low-emittance coatings, passive, solar

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Optimization studies of chemical vapour deposition techniques and film properties

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 02SX.31155-2-2756

STATUS: COMPLETED

CONTRACT START DATE: 83 01 06 COMPLETION DATE: 84 01 02

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$65 468

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this contract was to develop electrostatic spray techniques for depositing selectively reflecting thin film coatings on window glass. These films of semiconducting oxides are designed to transmit in the visible while reflecting the infrared radiation thus blocking radiant heat losses but permitting solar heating.

Studies made at the outset of the contract showed that commercially available electrostatic spraying equipment were inadequate for the designated task and therefore a film growing apparatus was designed and built in-house. The starting solution is passed through an atomiser and the upward travelling droplets go through a corona discharge becoming electrostatically charged. The target glass substrate is electrically at ground and heated to 400-450°C to enable a successful oxide film deposition to be accomplished.

The work was confined to the growth of SnO_2 films typically 0.5-2 μm in thickness and doped with either fluorine or antimony to attain the desired infrared reflectivity. Since the technique relies on the use of a low conductivity solvent ethyl acetate was used with the solutes being $SnCl_4$, $SbCl_3$, and SnF_4. Significant inprovement in film uniformity was achieved by the use of the electric charge. The resultant films were found to have transmissivities in the 70-80% range over the whole visible range of the spectrum and infrared reflectivities at 10 μm of 60-65%.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A 0S2. The full report contains proprietary information and is not available at this time.

KEY WORDS: Low-emissivity, glass coatings, CVD, Super windows

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Structural polyurethane window frame for thick airspace window. Phase 1	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 02SX.31155-2-2758
STATUS: COMPLETED	
CONTRACT START DATE: 83 01 11	COMPLETION DATE: 83 05 04
CONTRACTOR: GID Ltd. 477 boul. Champlain Québec, Qué. G1K 4J4	PRINCIPAL INVESTIGATOR: Paul-André Cloutier (418) 522-3881
NRC PROJECT MANAGER: K. Lund Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $50 384	FUNDING AGENCY: Solar Energy Program National Research Council Canada Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The objective of this study was to develop a low conductance window framing system of which the structure is largely polyurethane.

A detailed investigation was made of material properties and fabrication processes. In developing the design, key design issues addressed included: interface with vapour/air barrier and super-insulated construction, cold weather performance, material durability, and ease of installation. Detailed prototype working drawings were developed. Phase two of the project will involve the construction and testing of full scale prototypes. (See DSS File No. 07SX.31926-3-0074).

REPORTS AND REFERENCE SOURCES: The deliverables for this contract were the working drawings. A project digest will be made available following the Phase II work.

KEY WORDS: Super windows, window frame, polyurethane

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Thick airspace pressure equalization systems

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 04SX.31155-2-2759

STATUS: COMPLETED

CONTRACT START DATE: 83 05 11 COMPLETION DATE: 84 02 29

CONTRACTOR:
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CONTRACT PRICE:
$49 800

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

One option for super-window design is a sealed, thick airspace, multi-layer glazing unit. With conventional sealed units, the airspace thickness is limited because of barometric pressure stress. The objective of this work was to develop three methods of pressure equalization that would allow the airspace thickness of a sealed unit to be increased to 50 mm or more with no restriction on window size. The three methods examined were:

1) venting to the exterior through a drying agent (vented drier);
2) addition of an expansion bladder to the window (expansion bladder); and
3) provision for movement of the interim glazing layer to take up volume changes (movable glazing).

Models and prototypes of the three types were constructed. Detailed cost estimates were made. The study concluded that the vented drier system is the least expensive. If the dessicant containers are made reusable the cost is decreased even further. The vented drier system, however, must be actively maintained. This is a serious disadvantage that would cause considerable resistance to its use. The expansion bladder system does not require active maintenance but would be considerably more expensive. The bladders also restrict the placement of the window and complicate installation. The movable glazing is the most expensive system but it does not require active maintenance and closely fits present installation and operating practice. The use of plastic for the spacer in the movable glazing system requires further testing to determine its durability.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road., Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Glazing units, super windows, solar, passive, thick airspace

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of infrared reflective coatings using sol-gel technology	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 02SX.31926-3-0012
STATUS: COMPLETED	
CONTRACT START DATE: 83 04 01	COMPLETION DATE: 84 03 30
CONTRACTOR: Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario L5K 1B3	PRINCIPAL INVESTIGATOR: G. Gowda (416) 822-4111
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $49 214	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The work done under this contract successfully demonstrated that it is feasible to produce semiconducting, oxide coatings by the sol-gel technology which are transparent in the visible part of the spectrum and reflecting in the infrared region. The sol-gel dip coating technique consists essentially of inserting the substrate into a solution containing hydrolyzable metal compounds and pulling it out at a constant speed into an atmosphere containing water vapour. In this atmosphere hydrolysis and condensation take place. As a final step the films are hardened by a high temperature annealling process to form transparent metal oxides.

The specific objective of this work was the fabrication of doped SnO_2 films. The starting material was tri(IV)isobutoxide, available as a solution in isobutanol, which was mixed with ethanol and acetyl acetone. To obtain fluorine doped films trifluoracetic acid, hydrofluoric acid, or tin fluoride was added whilst to incorporate antimony, antimony pentachloride or antimony trichloride was used. The glass substrates were initially etched in an alkali solution and dipped into the oxide solution for 3 minutes prior to withdrawal at a constant speed. The substrates were allowed to dry for 24 hours in a humid atmosphere at room temperature and then given a heat treatment. The most promising heat treatment was found to be 1 to 2 hours at 530°C in argon.

At the conclusion of the work uniform coatings of $\sim$0.3 μm thickness could be consistently produced which had better than 90% transmissivity in the visible part of the spectrum and a reflectivity of $\sim$50% at 9.5 μm wavelength.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, passive, glazing, selective coatings

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design and construction of a window frame for a thick airspace window. Phase II	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 07SX.31926-3-0074
STATUS: COMPLETED	
CONTRACT START DATE: 83 06 02	COMPLETION DATE: 84 03 15
CONTRACTOR: GID Limited 477 boulevard Champlain Québec, Québec G1K 4J4	PRINCIPAL INVESTIGATOR: P.-A. Cloutier (418) 522-3881
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $88 867	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of the study was to develop a low conductance window framing system using structural polyurethane. Four full-scale prototypes were constructed and further work will involve testing the performance of these units. The window frame is non-openable and ventilation is to be provided through insulated openable shutters. The window frame is designed for thick wall, super-insulated construction and the design can be easily modified for different wall thicknesses. The exterior frame is designed to reflect daylighting into the building. A levelling system is incorporated into the window frame system.

REPORTS AND REFERENCE SOURCES: GID Limited intends to manufacture and market this product. The contract report contains blueprints for the design and is therefore proprietary. Release of the report will be reconsidered in 12 months.

KEY WORDS: Solar, passive, super windows

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Heat mirrors for retrofit window insulation

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	02SX.31926-3-3012
STATUS: IN PROGRESS AS OF:	84 01 31		
CONTRACT START DATE:	83 10 31	COMPLETION DATE:	84 08 28
NEXT MILESTONE & DATE:	84 08 28		

CONTRACTOR:
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CONTRACT PRICE:
$59 483

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The objectives of this study are twofold: first, to systematically study the long-term stability and durability of a ZnO/polyester heat mirror developed at the University of British Columbia, and second, to assess the suitability of the ZnO/polyester material for retrofit window applications. This second objective will involve both demonstrating that the heat mirror material can be attached to a window in a manner acceptable by a homeowner and also, developing a simple installation method which could be carried out by the homeowner.

KEY WORDS: Solar, passive, heat mirror, insulation, zinc oxide

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Load managed water heater for space and solar/DHW heating for low energy housing		
OERD REFERENCE NO:	4.2.2	DSS FILE NO:	04SX.31926-3-3016
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 11 03	COMPLETION DATE:	85 07 05
NEXT MILESTONE & DATE:	85 07 05		

CONTRACTOR: Zero Energy Products Ltd. P.O. Box 2283 Brampton, Ontario L6T 2T0	PRINCIPAL INVESTIGATOR: M. Lostracco (416) 792-7248
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $20 642	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The study objective is to develop a load managed space heating and DHW system for low-energy buildings which can also incorporate an active solar system. The tasks to be carried out include developing design criteria based on existing peak load data for low-energy houses. A prototype will be constructed and installed in a low-energy demonstration house.

KEY WORDS: Solar, passive, DHW, space heating

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Aerogel transparent insulation for super window technology

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	02SX.31926-3-3032
STATUS: IN PROGRESS AS OF:	83 01 31		
CONTRACT START DATE:	83 11 30	COMPLETION DATE:	84 11 30
NEXT MILESTONE & DATE:	84 11 30		

CONTRACTOR:
E.J. Faraci & Associates Ltd.
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$62 741

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop transparent insulation for super window glazing. Sample materials will be prepared on a laboratory scale and a series of tests for optical, thermal, and structural performance will be carried out.

KEY WORDS: Solar, passive, window, aerogel, insulation, silica, alumina

NRC/SEP PROJECT SUMMARY SHEET

INTERIM

PROJECT TITLE: Replaceable foam insulation. Phase I

OERD REFERENCE NO: 4.2.2

DSS FILE NO: 02SX.31926-3-3033

STATUS: IN PROGRESS AS OF: 84 01 03

CONTRACT START DATE: 83 10 19

COMPLETION DATE: 84 05 15

NEXT MILESTONE & DATE: 84 05 15

CONTRACTOR:
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CONTRACT PRICE:
$66 205

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this study is the development of large glazing cavity moveable insulation systems for sunspaces, greenhouses, and atriums. The insulation system is based on high expansion, liquid foams between glazings. The work to be carried out includes testing of alternative liquid foams to determine structural and flow characteristics as well as optical and thermal properties. Problems of "scaling-up" will also be investigated.

KEY WORDS: Solar, passive, insulation, super windows, greenhouses

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Programmable controller for attached sunspace

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	02SX.31926-3-3049
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	84 02 27	COMPLETION DATE:	84 03 14
NEXT MILESTONE & DATE:	84 03 14		

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$50 124

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the project is to develop a programmable controller for attached sunspaces.

The first phase will involve the development of the controller subroutine and the computer simulation of alternative control and operating strategies.

KEY WORDS: Solar, passive, simulation, controller, sunspace

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Evacuated glazing panel

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 05SR.31926-3-3055

STATUS: IN PROGRESS AS OF: 84 04 30

CONTRACT START DATE: 84 03 08 COMPLETION DATE: 84 12 20

NEXT MILESTONE & DATE: 84 12 20

CONTRACTOR:
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Whitby, Ontario
L1N 6P4

PRINCIPAL INVESTIGATOR:
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CONTRACT PRICE:
$107 262

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this project is to develop an evacuated glazing panel.

The tasks include structural analysis, materials testing, prototype fabrication, and evaluation.

KEY WORDS: Solar, passive, vacuum, spacer, edge seal, super window

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of thin film heat mirror coating

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 07SX.31926-3-5004

STATUS: COMPLETED

CONTRACT START DATE: 83 10 13 **COMPLETION DATE:** 84 03 30

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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CONTRACT PRICE:
$24 973

FUNDING AGENCY:
Solar Energy Program
National Research Council
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Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

First generation low emittance multilayer films are not sufficiently stable or durable to withstand the normal environment experienced by window glazings. In view of this situation the main objective of this contract was to select materials known to be intrinsically more resistant and determine whether their optical properties make them suitable for heat mirror applications. This feasibility study along with theoretical calculations indicated that multilayer structures based on TiN with TiO_2 or ZrO_2 as anit-reflective coatings have the potential to compete with existing products and are inherently more durable.

Films of these three compounds were prepared by electron beam evaporation onto glass substrates held at 300°C. Although this preparation technique would be too expensive to use in production it provides excellent control of growth conditions for laboratory specimens. Good quality uniform golden films of TiN were fabricated and some three layer structures of TiO_2/TiN/TiO_2 were produced from metallic Ti by switching the admitted gas during growth. No attempt was made to optimise the optical properties of the produced films during this short-term contract. However, the experimental work done demonstrated the promise of these particular multilayer heat mirror structures.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, passive, heat mirror, metal-dielectric multi-layer films

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Aerogel insulation for super window glazing

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 07SX.31926-3-5005

STATUS: IN PROGRESS AS OF: 84 01 03

CONTRACT START DATE: 83 09 30 COMPLETION DATE: 84 07 31

NEXT MILESTONE & DATE: 84 07 31

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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$46 500

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop transparent silica aerogel insulation for super-window glazing. Sample materials will be prepared on a laboratory scale and various heat treatment options will be evaluated.

KEY WORDS: Solar, passive, glazing, aerogel, insulation, silica

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Edge seal design with flexible plastic inner glazing

OERD REFERENCE NO:	4.2.2	DSS FILE NO:	02SX.31926-3-5006
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 11 16	COMPLETION DATE:	84 06 30
NEXT MILESTONE & DATE:	84 06 30		

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CONTRACT PRICE:
$14 755

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop an insulated edge seal design for sealed, thick air space, multi-layer glazing units with the capability of withstanding pressure stress due to heat build-up. For the design of the glazing system, the focus is on the use of thin flexible plastic substrate heat mirror and/or high transmission inner glazing layers.

KEY WORDS: Solar, passive, glazing, edge seal, thick air space

NRC/SEP PROJECT SUMMARY SHEET

INTERIM

PROJECT TITLE: Integrated DHW heat pump/storage system for passive solar, low-energy houses

OERD REFERENCE NO: 4.2.2

DSS FILE NO: 04SX.31926-3-5007

STATUS: IN PROGRESS AS OF: 84 01 03

CONTRACT START DATE: 83 09 30

COMPLETION DATE: 84 05 15

NEXT MILESTONE & DATE: 84 05 15

CONTRACTOR:

Allen Drerup White Ltd.
334 King Street East
Studio 505
Toronto, Ontario M5A 1K8

PRINCIPAL INVESTIGATOR:

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NRC PROJECT SCIENTIST:

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CONTRACT PRICE:

$42 882

FUNDING AGENCY:

Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop an integrated mechanical/storage system with heat pump upgrade, ventilation heat recovery, and combined space and domestic hot water tank storage.

KEY WORDS: Solar, passive, storage, heat pump, domestic hot water

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE Resin micro-encapsulation for liquid/solid PCM's

OERD REFERENCE NO: 4.2.2	DSS FILE NO: 07SX.31926-3-5008
STATUS: IN PROGRESS AS OF: 84 01 03	
CONTRACT START DATE: 83 09 30	COMPLETION DATE: 84 07 31
NEXT MILESTONE & DATE: 84 07 31	

CONTRACTOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$44 851

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop a resin micro-encapsulation system for liquid/solid phase-change materials (PCM). Sample materials will be prepared and the material characteristics evaluated including heat transfer, heat storage capacity, and long term effectiveness.

KEY WORDS: Solar, passive, encapsulation, phase-change materials

NRC/SEP PROJECT SUMMARY SHEET

INTERIM

PROJECT TITLE: Composite polyurethane openable window frame systems

OERD REFERENCE NO: 4.2.2

DSS FILE NO: 07SX.31926-3-5009

STATUS: IN PROGRESS AS OF: 84 02 16

CONTRACT START DATE: 83 10 31

COMPLETION DATE: 84 07 31

NEXT MILESTONE & DATE: 84 07 31

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CONTRACT PRICE:
$57 200

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop prototype designs for composite polyurethane/PVC and polyurethane/metal openable window frame systems.

The main design criteria for low conductance window frame systems are to be identified along with key problem areas relating to long-term performance. Test samples of composite polyurethane/PVC and polyurethane/metal window frame systems will be fabricated and structural and thermal performance testing carried out.

KEY WORDS: Solar, passive, polyurethane, PVC, metal, window frames

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Polyethylene honeycomb moveable insulation for attached sunspace		
OERD REFERENCE NO:	4.2.2	DSS FILE NO:	04SX.31926-3-5010
STATUS: IN PROGRESS AS OF:	83 01 31		
CONTRACT START DATE:	83 10 26	COMPLETION DATE:	84 11 30
NEXT MILESTONE & DATE:	84 11 30		

CONTRACTOR:
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1465 Russell Rd. N.E.
Calgary, Alberta
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PRINCIPAL INVESTIGATOR:
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CONTRACT PRICE:
$18 250

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of the study is to develop a polyethylene honeycomb moveable insulation system incorporating an inflated polyethylene core for attached sunspaces.

The study comprises material selection with emphasis on durability and cold weather performance, production of preliminary working drawings for prototype construction, and construction, testing, and modification of a prototype moveable insulation system. This will be followed by the installation of the prototype on a full-scale greenhouse facility. The monitoring methodology to be used on this system will be assessed during the course of the contract.

KEY WORDS: Solar, passive, window, insulation, commercial greenhouses

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Optimization of heat mirror coating for flexible substrate

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 04SX.31926-3-5011

STATUS: COMPLETED

CONTRACT START DATE: 83 10 26 COMPLETION DATE: 84 03 30

CONTRACTOR:
Corona Vacuum Coaters Inc.
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$30 063

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The major work of this contract consisted of optimising the design and usage of planar magnetron sputtering equipment for the growth of thin films on flexible polyester substrates. A sputtering source, well suited to high rate reactive sputtering and featuring a very high, extremely uniform magnetic field and efficient cooling, had previously been developed. A baffle cage was installed to inhibit the flow of oxygen to the target surface, thereby giving a wide range of possible oxygen partial pressures for stoichiometric film growth in the presence of a bare metal surface target. Radiofrequency (RF) electrodes were installed behind the moving plastic web substrate to enable the RF energy to clean the substrate surface and increase the oxidation rate. This RF discharge was found to be vital to the growth of ZnO, SnO_2, and SiO_2 but not required for Al_2O_3 or ZrO_2.

By the conclusion of the contract the process could be controlled to achieve 2% thickness uniformity across a one-metre web. Thin film heat mirrors of both the single layer semiconducting type (ZnO, SnO) and the multilayer type (ZrO_2/Al/ZrO_2, SnO_2/Al/SnO_2) on 2-mil polyester were fabricated. The measured transmissions in the visible wavelength region were in the 65-70% range (bare polyester has transmission of about 80%) and the reflectivities at 10 um varied between 70 and 85%. Of the three layer structures the ZrO_2/Al/ZrO_2 combination was visually particularly attractive being light blue in colour.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2. The full report contains proprietary information and is not vailable at thi time.

KEY WORDS: Solar, passive, heat mirror, magnetron sputtering

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Preparation of heat reflecting films on glass using electrostatic spray deposition	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 03ST.31926-3-5039
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 84 02 08	COMPLETION DATE: 85 01 04
NEXT MILESTONE & DATE: 85 01 04	
CONTRACTOR: Simon Fraser University Energy Research Institute Burnaby, B.C. V5A 1S6	PRINCIPAL INVESTIGATOR: S.R. Morrison (604) 299-4465
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $160 188	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The study objective is to develop a uniform heat reflecting coating on glass using electrostatic spray deposition. The second phase of the project includes the analysis and optimization of the films, durability studies, and the construction of a multiple nozzle sprayer.

KEY WORDS: Solar, passive, window, tin oxide

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Evaluation of graphic manual methods for passive design

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 05SX.31155-2-2765

STATUS: COMPLETED

CONTRACT START DATE: 83 02 23 COMPLETION DATE: 84 02 29

CONTRACTOR:
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Don Mills, Ontario, M3B 2S7

PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$51 340

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The purpose of this study was to evaluate three manual graphic design methods for use by designers at the conceptual design phase of small to medium size commercial buildings.

Three methods were initially evaluated: (i) Energy Graphics (ii) G-SEET, and (iii) Energy Nomographs. Following preliminary review, it was concluded that the Energy Nomographs method was potentially the most accurate and the easiest to use. The accuracy of all methods for estimating passive solar gains, however, was relatively low. A more detailed study of Energy Nomographs was carried out. This involved carrying out test calculations for different building types and comparing the results with an hourly simulation model. The study identified, a number of limitations, including: inability to account for temporary storage; errors in the estimation of solar gains; and limited ability to model the effects of alternative mechanical systems. From the user view point, the method was time consuming and confusing. In addition, no visual guidance was given to the designer on what are the sensitive factors and what should be done next to improve the design. Recommendations are given on the type of graphic design tools that should be developed for the preliminary design stage.

REPORTS AND REFERENCE SOURCES: The project digest is available as report no. Passive-12-D from Publication, Sales & Distribution. The digest and full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Monreal Road, Building R-105, Ottawa, Ontario, K1A OS2.

KEY WORDS: Manual design tools, commercial buildings, passive, solar

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Computer simulation of attached sunspaces

OERD REFERENCE NO: 4.2.2	**DSS FILE NO:** 02SX.31155-2-2776
STATUS: COMPLETED	
CONTRACT START DATE: 82 08 20	**COMPLETION DATE:** 83 10 10
CONTRACTOR: Watershed Energy Systems Ltd. 97 Six Point Road Toronto, Ontario M3Z 2X3	**PRINCIPAL INVESTIGATOR:** R. Barker (416) 233-3241
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	**NRC PROJECT SCIENTIST:** M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $52 484	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The purpose of this study was to determine through hour-by-hour computer simulation the performance of different types of attached sunspaces. A computer program, MENFIS, previously developed by Watershed was modified to model the alternative sunspace options. The modified program was tested against measured hour-by-hour data from test sunspaces in Los Alamos, California. MENFIS appeared able to predict indoor temperatures, auxiliary heating requirements and heat transfer to the parent building to within an acceptable range of measured values. Preliminary runs using the MENFIS program were carried out on different system designs. The results are not reported due to uncertainty on the capability of the program to model some of the system options. The project was terminated at this stage. A detailed cost analysis of nine alternative sunspace designs was carried out. (See Appendix A Project Digest).

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Passive, solar, attached sunspaces, computer simulation

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Computer simulation of super windows

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 07SX.31155-2-2778

STATUS: COMPLETED

CONTRACT START DATE: 83 01 31 **COMPLETION DATE:** 83 09 30

CONTRACTOR:
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CONTRACT PRICE:
$44 017

FUNDING AGENCY:
Solar Energy Program,
National Research Council
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Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The objective of this work was to develop a FORTRAN program capable of modelling the combined optical and thermal performance of super windows. The program written to meet this goal, called VISION, is capable of modelling conventional, as well as innovative, multi-glazed windows incorporating such features such as diathermanous glazings, substitute gases or gas mixtures, partial vacuums, convection suppression slits, thin film coatings, and shading devices including overhangs, side fins, and set back. Window tilt can range from 0 to 180 degrees.

The program provides the analyst with two methods to evaluate thermal performance. The first method involves the calculation and comparison of window U-value and shading coefficient. The second method enables the analyst to calculate hourly heat transfer through the window for any period up to one year in length, for as many as 8 different window orientations.

Window optical performance is characterized primarily using classical optical theory. The unique functional dependence of optical properties on radiation incidence angle is characterized using coefficients for a fifth order polynomial. This approach minimizes execution time requirements for the hourly energy analysis.

Convective/conductive/thermal radiation heat transfer between glazings and between the window and the environment are analysed using a rigorous algorithm.

Initial computer runs show VISION to agree well with published values.

REPORTS AND REFERENCE SOURCES: Available as SEP contract report no. Passive 10 from Publication Sales and Distribution Office, National Research Council, Bldg. M-58, Montreal Road, Ottawa, Ontario, K1A OR6 or on loan from the Canada Institute for Scientific and Technical Information (Energy Library)

KEY WORDS: Super windows, computer simulation, modelling

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Evaluation of passive solar design tools for residences

OERD REFERENCE NO: 4.2.2	**DSS FILE NO:** 04SX.31926-3-0028
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 07 29	**COMPLETION DATE:** 84 07 20
NEXT MILESTONE & DATE: 84 07 20	

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CONTRACT PRICE:
$98 412

FUNDING AGENCY:
Solar Energy Program
National Research Council
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Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

An increasing number of design tools and computer programs are being marketed in Canada to assist in the design of passive solar systems for residential buildings.

The objective of the current study is to provide the potential purchaser/user of such design tools with a means of selecting the most appropriate tools for his own specific requirements and circumstances.

The objective is to be met through a three stage work program:

(i) Review and data collection. Based on the results of this stage, the procedures defined in subsequent steps will be reassessed.
(ii) Short-listing of design tools for detailed evaluation and the development of the evaluation methodology.
(iii) Evaluation of the design tools. This will involve both technical evaluation and user evaluation. Each tool will be used to simulate the performance of the NRC reference house.

KEY WORDS: Solar, passive, design tools

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Computer simulation of the thermal performance of super windows	
OERD REFERENCE NO:	4.2.2	DSS FILE NO: 04SX.31926-3-0115
STATUS: IN PROGRESS AS OF:	84 04 30	
CONTRACT START DATE:	83 11 22	COMPLETION DATE: 84 06 30
NEXT MILESTONE & DATE:	84 06 30	

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CONTRACT PRICE:
$19 154

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The intent of this study is to determine the thermal performance sensitivity of several window designs to variations in design parameters and to identify optimal configurations.

The VISION program (see contract no. 07SX.31155-2-2778) will be used to calculate the thermal performance of windows with between one and four glazings. The design parameters to be investigated include variations in interpane spacing, use of inert gases, reduced interstitial gas pressure, use of optical coatings, and use of thin glass or films for interior surfaces. Weather parameters from Vancouver, Winnipeg, and Ottawa and three window orientations will be used in calculating net thermal efficiencies.

KEY WORDS: Solar passive, simulation, super windows

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance evaluation of the "Solar 2000" passive solar residence	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31155-2-2779
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 83 01 31	COMPLETION DATE: 84 07 15
NEXT MILESTONE & DATE: 84 07 15	
CONTRACTOR: Allen-Drerup-White 334 King St. East, Studio 505 Toronto, Ont., M5A 1K8	PRINCIPAL INVESTIGATOR: G. Allen (416) 863-1762
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Colley Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $36 521	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The low energy passive solar house "Solar 2000" is to be monitored during the 1982 - 1983 heating season and the passive contribution to the heating load evaluated. One-time tests will be performed to measure parameters associated with the thermal properties of the house and the operation of the heating and ventilation equipment. Continuous monitoring of inside and outside temperatures, thermal mass, and various energy inputs will be carried out.

KEY WORDS: Solar, passive, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance evaluation of the Laurin passive solar residence

OERD REFERENCE NO:	4.2.2	CONTRACT NO:	04SX.31155-2-2780
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	82 10 29	COMPLETION DATE:	84 07 20
NEXT MILESTONE & DATE:	84 07 20		

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CONTRACT PRICE:
$23 526

FUNDING AGENCY:
Solar Energy Program
National Research Council Canada
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PROJECT OBJECTIVE AND DESCRIPTION:

The Laurin passive solar residence is to be monitored for a period of 12 months at the SERI Level B.

Sufficient one-time tests and dynamic monitoring using an Aeolian Kinetics PDL-24 data acquisition system will be carried out so that monthly, seasonal, and annual energy contribution of the passive systems can be determined with reasonable accuracy. A standard-format "site-handbook" is to be prepared, the incremental cost of the passive solar features identified, and the monitored results compared to the design program's predictions.

KEY WORDS: Solar, monitoring, passive, Level B

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Performance evaluation of the Bower passive solar residence

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 04SX.31155-2-2781

STATUS: COMPLETED

CONTRACT START DATE: 82 10 29 **COMPLETION DATE:** 83 09 30

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CONTRACT PRICE:
$20 520

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A 140 m^2 two storey super insulated house with a 22 m^2 attached sunspace was monitored over the fall, winter and spring of the 1982/83 heating season. The monitoring program conformed to Level B for the winter and spring period and to a Level C+ during the fall.

The primary passive system consists of a two storey attached sunspace from which heated air is ducted to a 79 m^2 crawlspace which has a 100 mm layer of gravel to provide thermal storage.

The estimated passive solar contribution for the period December to April is 35%. This combined with owner/occupant claims of comfortable living conditions in all seasons suggests that the house is performing very well.

The original monitoring did not adequately address the performance of the crawlspace gravel bed storage system. A follow-on study (04SX.31926-3-5025) is addressing the crawlspace gravel bed in detail.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, passive, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance evaluation of the Lister passive solar residence

OERD REFERENCE NO:	4.2.2	CONTRACT NO:	04SX.31155-2-2782
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	82 10 29	COMPLETION DATE:	84 07 31
NEXT MILESTONE & DATE:	84 07 31		

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CONTRACT PRICE:
$23 135

FUNDING AGENCY:
Solar Energy Program
National Research Council Canada
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The "Lister" passive solar low energy house is to be monitored through the 1982/83 Heating Season at a level similar to the SERI Level B. The Lister residence has 205 m^2 of living area, and an 11 m^2 attached sunspace.

Campbell Scientific CR21 Data Loggers will be employed for data collection. These machines have a 10 second scan interval, but will reduce the data to hourly values which will be stored on cassette tape and analyzed at SOLAR offices.

Initial one time tests of air tightness, overall heat loss coefficients, furnace efficiency, etc., will be performed to quantify critical building energy performance characteristics, followed by an extended period of data logging and analysis.

KEY WORDS: Solar, passive, monitoring

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Performance evaluation of the Wilson passive solar residence

OERD REFERENCE NO: 4.2.2 **DSS FILE NO:** 04SX.31155-2-2783

STATUS: COMPLETED

CONTRACT START DATE: 82 10 29 **COMPLETION DATE:** 84 03 31

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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$29 775

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A passive solar home, the Wilson residence, has been monitored over the 1983-1984 heating season using an Aeolian Kinetics PDL-24 data acquisition system. The procedures used were those established by the Solar Energy Research Institute for Level "B" monitoring.

This is a two storey 134-m^2 house bermed on the north. North glazing is limited to 0.5 m^2, east and west 2 m^2 each, and south glazing is 17.7 m^2. Approximately 1/3 of the glazing is triple, 2/3 is double. A concrete floor slab provides additional solar thermal storage. To facilitate measurement, the original auxiliary heating system (wood) was replaced by electric baseboards for the monitoring period.

This house has performed as expected. Through the period August - February, passive performance was in the range of 28%, with internal gains contributing 27% and the auxiliary system contributing 45%. The house infiltration load has been found to be strongly directionally dependent.

Performance of the Wilson House 1983/84

	Load MJ	Auxiliary MJ	Internal Gains MJ	Useful Passive MJ
Sept.	2824	0	630	2194
Oct.	5316	1402	656	3268
Nov.	7768	4931	1807	1030
Dec.	10388	5908	3052	1428
Jan.	12534	6162	3059	3313
Feb.	9543	4478	2684	2381

REPORTS AND REFERENCE SOURCES: This final report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library) National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, passive, monitoring, Level B

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Preparation of a Level B monitoring manual

OERD REFERENCE NO: 4.2.2
DSS FILE NO: 07SX.31155-2-2785
STATUS: COMPLETED 83 06 14
CONTRACT START DATE: 82 11 15
COMPLETION DATE: 83 10 31

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CONTRACT PRICE:
$31 675

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
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PROJECT PRECIS:

The National Research Council/Solar Energy Program has established a "Level B" performance evaluation program in order to quantify the thermal contribution of passive solar elements in representative, occupied passive solar homes. This manual provides all the background information, standard procedures and other guidance necessary to conduct "Level B" monitoring. It recognizes the uniqueness and variability of individual monitoring situations, but also delineates many areas where standardization is useful. The key issues addressed relate to one-time and continuous measurements, monitoring equipment, definitions of performance factors, practices for treatment of various building elements, data analysis, non-instrumented performance evaluation, and reporting format.

Instrumentation is limited to that needed to characterize the outdoor and indoor environments, and to calculate the monthly building energy balance, including all but one of the major elements in the energy balance: the solar contribution. The passive solar heating component is subtractively calculated using measured values of building heat loss, internal gains and auxiliary heating. Thermal storage and other individual components do not have to be instrumented and the program makes no attempt to evaluate a building's thermal processes in detail.

Level B monitoring uses on-site processing of data and displays performance results using a microprocessor data acquisition system. Off-site "post analysis" of the monitoring results is only required for activities such as regression analysis, comparative analysis of data from different sites, and error correction. This data processing arrangement has been shown to increase the reliability, ease of handling and credibility of the monitored data and to facilitate debugging and maintenance of the data acquisition system.

REPORTS AND REFERENCE SOURCES: Available as SEP Contract report No. Passive-8 from Publications Sales & Distribution, National Research Council, Bldg. R-88, Montreal Road, Ottawa, Ontario, K1A 0R6 or on loan from CISTI.

KEY WORDS: Monitoring, performance evaluation, passive, solar, low energy building

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance evaluation of the Efstonscience Building	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31155-2-2788
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 83 02 22	COMPLETION DATE: 84 06 29
NEXT MILESTONE & DATE: 84 06 29	
CONTRACTOR: Buchan, Lawton, Parent Ltd. 325 Dalhousie Street, Ste.700 Ottawa, Ontario, K1N 7G2	PRINCIPAL INVESTIGATOR: D. Buchan (613) 233-7724
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Colley Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $44 896	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The Efstonscience passive-solar low-energy building will be evaluated and monitored for one year to determine the effectiveness of the building design in reducing energy consumption.

The Efstonscience building has 1000 m^2 of useable space and incorporates direct passive gain, heat recovery and storage of excess heat gains with heat pump upgrade, perimeter and roof daylighting, and summer shading of glazed areas.

A base-case building design will be determined and the performance of the actual and base-case buildings simulated using the "BLAST" program. A philosophy for Level C monitoring of the building will be developed and implemented. This will be enhanced by two 2-week periods of in-depth monitoring. The effectiveness of the monitoring strategy will be assessed after the one year monitoring period. The performance of each component of the building is to be estimated and quality of the building environment evaluated.

KEY WORDS: Solar, passive, monitoring, Level C, BLAST

NRC/SEP PROJECT SUMMARY SHEET

INTERIM

PROJECT TITLE: Monitoring of the thermal performance of a passive solar house in Winnipeg

OERD REFERENCE NO: 4.2.2

DSS FILE NO: 04SX.31155-2-2873

STATUS: IN PROGRESS AS OF: 84 03 30

CONTRACT START DATE: 83 03 31

COMPLETION DATE: 84 08 31

NEXT MILESTONE & DATE: 84 08 31

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CONTRACT PRICE:

$33 316

FUNDING AGENCY:

Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The purpose of this work is to determine the performance of an extremely tight, well insulated passive solar (direct gain) residence in a cold climate. The project will employ an Aeolian Kinetics PDL-24 data acquisition system which will provide a continuous record of the building's performance over a 15 month period.

The work program will consist of:

(i) a series of one time tests to establish the building's thermal performance characteristics: overall heat loss coefficient, airtightness, water heater jacket loss, cooldown time constants, air-to-air heat exchanger efficiency, and flow rates.

(ii) an extended period of continuous dynamic performance data collection and analysis, including the following points: insolation on a horizontal surface, insolation on the vertical south face, insolation through the glazing, outdoor dry-bulb temperature, auxiliary space heating energy, water heater consumption, indoor appliance energy consumption, air temperatures in the attic, garage, basement, and living space, basement floor and wall (behind insulation) temperatures, air-to-air heat exchanger operation, window shutter position, and exterior door use.

The data will be analyzed by the contractor and reported on quarterly.

KEY WORDS: Solar, passive, monitoring, Level B

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Passive solar monitoring of the Dwornik Residence

OERD REFERENCE NO: 4.2.2	DSS FILE NO: 028X.31926-3-0096
STATUS: IN PROGRESS AS OF: 83 12 08	
CONTRACT START DATE: 83 09 13	COMPLETION DATE: 85 03 06
NEXT MILESTONE & DATE: 85 03 06	

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CONTRACT PRICE:
$46 529

FUNDING AGENCY:
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PROJECT OBJECTIVE AND DESCRIPTION:

A passive solar home in Lethbridge Alberta will be monitored for a period of 18 months at level B using an Aeolian Kinetics PDL-24 data acquisition system. The home, called the Dwornik Residence, is a small light weight structure with an attached sunspace and was built under the EMR sponsored S.E.E.H. program in 1982. Preliminary air tightness tests showed the structure to be extremely tight (0.27 ach @ 50 Pa).

The tasks that will be carried out by MacLaren Plansearch Ltd. include:

- review and refinement of project plan,
- off-site testing of the monitoring system,
- monitoring and data reduction software development,
- purchase of sensors,
- detailed design and specification of sensor network,
- installation and commissioning of monitoring system,
- 18 months data collection and data reduction,
- periodic presentation of results,
- one-time testing for: infiltration, heat loss factor, building time constant, and
- extension of existing tests to quantify the thermal performance of selected building components.

KEY WORDS: Solar, passive, residential, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance monitoring of the Shantz passive solar home

OERD REFERENCE NO: 4.2.2 DSS FILE NO: 04SX.31926-3-0098

STATUS: IN PROGRESS AS OF: 83 12 14

CONTRACT START DATE: 83 09 30 COMPLETION DATE: 85 01 31

NEXT MILESTONE & DATE: 85 01 31

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CONTRACT PRICE:
$27 267

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The performance of the Shantz passive solar house in Nova Scotia is to be monitored for a period of one year. During this time an evaluation of the level B monitoring methodology will be carried out.

Sensor placement to carry out the level B monitoring will be determined and the sensors and related materials purchased and installed. Manual and one-time measurements will be taken and an initial performance calculation carried out. The data logger system will be checked and installed.

After an initial month of operation, any sensor deficiencies will be corrected. Monthly site visits and weekly phone calls will be made to ascertain the proper operation of the system and any areas of concern will be reported. The contractor will produce monthly monitoring reports and a detailed final report of the building's performance.

KEY WORDS: Solar, passive, monitoring, level B

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Performance evaluation of a greenhouse freeze-protected solar DHW system	
OERD REFERENCE NO: 4.2.2	DSS FILE NO: 04SX.31926-3-5001
STATUS: IN PROGRESS AS OF: 83 12 08	
CONTRACT START DATE: 83 08 04	COMPLETION DATE: 85 01 31
NEXT MILESTONE & DATE: 85 01 31	
CONTRACTOR: Solar Applications and Research Ltd. 3683 West 4th Avenue Vancouver, B.C. V6R 1P2	PRINCIPAL INVESTIGATOR: K. Cooper (604) 733-5631
NRC PROJECT MANAGER: M. Glover Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Colley Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $24 515	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Two domestic hot water systems, intended for greenhouse applications, are to be designed, installed, and tested. These systems will use uninsulated, unglazed, copper sheets mounted below the glazing of the greenhouse to absorb energy.

Phase I will focus on a detailed cost analysis and performance prediction task which will include:

- design of the prototype systems, one a thermosiphon, the other pumped;
- detailed analysis of current equipment costs;
- system thermal performance prediction using an established simulation tool; and
- estimation of the cost-effectiveness of the greenhouse (sunspace)/DHW combination.

Upon successful completion of Phase I, Phase II will address installation and testing of the prototypes through:

- installation of the two systems in an existing greenhouse;
- monitoring of the systems for a period of up to one year;
- intensive monitoring for two one-month periods; and
- analysis of the performance data collected and comparison with theoretical results from Phase I.

KEY WORDS: Solar, DHW, sunspace, thermosiphon, monitoring

NRC/SEP PROJECT SUMMARY SHEET

INTERIM

PROJECT TITLE: Level B monitoring. Phase II

OERD REFERENCE NO: 4.2.2

DSS FILE NO: 04SX.31926-3-5025

STATUS: IN PROGRESS AS OF: 83 12 14

CONTRACT START DATE: 83 09 30

COMPLETION DATE: 85 04 30

NEXT MILESTONE & DATE: 85 04 30

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CONTRACT PRICE:

$42 711

FUNDING AGENCY:

Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
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PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this study is to investigate the potential enhancement of the performance of a passive solar house through the use of:

(i) crawl space rock storage; and
(ii) ventilation air pre-heating using a sunspace.

The rock storage study will be carried out at the Bower passive solar house (previously monitored) using an Aeolian Kinetics PDL-24 data acquisition system. Approximately two months of continuous temperature and flow rate data will be collected and analyzed and the performance reported.

The ventilation air pre-heat study will be carried out on a passive solar house in Manotick. This study will be based on level B monitoring of the house over a 12-month period, with bi-monthly analysis of the monitored data. Overall house performance as well as specific component performance will be reported.

KEY WORDS: Solar, passive, pre-heating, rock storage

COMMERCIAL/INDUSTRIAL PROCESS HEAT

SECTION C

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NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Snow and wind loads resulting from roof mounting of solar collectors	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31155-2-2701
STATUS: COMPLETED	
CONTRACT START DATE: 82 12 02	COMPLETION DATE: 84 06 06
CONTRACTOR: Morrison, Hershfield, Theakston and Rowan Limited 650 Woodlawn Road West Guelph, Ontario, N1K 1B8	PRINCIPAL INVESTIGATOR: P. Irwin (519) 823-1311
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $72 459	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

This study was conducted to obtain wind and snow design guidelines for flat plate collectors.

The wind loading characteristics were obtained experimentally in the contractor's 1.8 x 2.8 m wind tunnel. Both normal forces and moments on the row-centre and row-end collectors were measured for various roof pitch angles, collector tilt angles, gap heights, row lengths, and for two row positions on the roof. Based on the experimental results, a design guideline was recommended which shows the pressure coefficient as a function of gap height, roof pitch angle, and whether the collector is a center or end collector.

Snow accumulation patterns were obtained by using computer simulations and by using the contractor's water flume. Computer simulations were used to determine snow pile-ups in the gap as a result of snowfalls. Water flume tests were used to obtain snow drift patterns as a result of wind blowing. Based on these studies, a design guideline for the minimum gap height to avoid blockage was recommended, and a few collector array patterns that can avoid significant snow drift build-ups were suggested.

REPORTS AND REFERENCE SOURCES: The project digest is available as Contract Report no. Coll-17-D from Publication, Sales & Distribution, National Research Council, Montreal Road, Building R-88, Ottawa, Ontario, K1A 0R6. The full report is available on loan from CISTI.

KEY WORDS: Solar, collector, wind, snow, guideline

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: An evaluation of the technical requirements of selected industrial sites for low temperature solar industrial process heat	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31155-2-2704
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 11	COMPLETION DATE: 83 09 19
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NRC PROJECT MANAGER: K.G. Lund Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: G. Yen Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $37 067	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this study was to provide the Solar Energy Program with a clearer understanding of solar industrial process heating (IPH) potential through detailed studies of the thermal processes involved in selected IPH sectors.

The work consisted of studying the following industrial sectors: (1) pulp and paper, (2) fruit and vegetable canning, (3) mining ore concentration, (4) slaughtering and meat processing, (5) dairy products, (6) soft drink bottling, (7) brewing, and (8) tanning.

Rough estimated data on up to 2 plants per sector was collected in order to determine the quantity and temperature of heat required, the load and load profile, and the possibility of the use of heat reclaim technologies. An assessment of the attitudes of management towards renewable energy technologies was carried out at the same time.

A preliminary feasibility study was performed for the application of low temperature glycol (<70°C) solar IPH systems to the five most promising sites after heat reclaim, conservation, and load resheduling had been applied. This sample was not large enough to permit broad generalizations to be made.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, IPH, heat reclaim

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Transient energy analysis of solar energy systems

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 04SX.31155-2-2787

STATUS: COMPLETED

CONTRACT START DATE: 82 12 31 COMPLETION DATE: 84 01 30

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CONTRACT PRICE:
$24 501

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT PRECIS:

A comprehensive computer literature search was carried out as Task I of a study to investigate random data reduction methods which could be applied to reduce the data obtained from a solar energy system (SES) operating under transient conditions. The literature search, however, did not identify any methods which could be readily used to reduce such data.

Therefore, the emphasis of this study was shifted to search for information on the transient performance of solar collectors. This search provided a comprehensive listing of relevant work. The most significant conclusions from this survey are:

i) The majority of the work is based on numerical or analytical techniques to solve the differential equations resulting from time-dependent collector modelling. These numerical techniques, such as finite difference, involve sophisticated computational work and therefore restrict their frequent use.

ii) Most of the work on transient collector analysis has dealt with thermal capacitance effects only. Limited work is available on transition time lag effects.

iii) Most of the experimental methods developed to adjust the as-measured (raw) data from a collector system require special indoor testing of collectors to calculate the adjusting factors.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A 0S2

KEY WORDS: Solar, industrial process heat, transient analysis

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Feasibility study of a single axis lamellar heliostat tracking (SALHT) collector	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31155-2-2861
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 05 27	COMPLETION DATE: 84 06 08
NEXT MILESTONE & DATE: 84 06 08	
CONTRACTOR: Petro-Sun International Incorporated 2290 de la Métropole Longueuil, Québec J4G 1E6	PRINCIPAL INVESTIGATOR: Jacques Sicotte (514) 670-8043
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CONTRACT PRICE: $31 325	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A feasibility study is to be carried out on the design of a cost-effective linear concentrating collector with an evacuated tube receiver for use in applications requiring process water or low pressure steam ranging from 80° to 200°C.

A theoretical study will be performed to determine the basic pamameters (dimensions, materials, concentration ratio, etc.) for the first prototype model. Optical efficiency calculations which are to be performed include: determining the effects of the lamellar heliostat dimensions on the concentration ratio; determination of the optimum width of the heliostats; estimation of the incident angle modifier, determination of the effect of alternative glazing locations. etc. The characteristics of several evacuated tubes are to be determined as a function of the SALHT collector's requirements. A theoretical calculation of the heat loss process as a function of different operating temperature ranges and header arrangements will also be performed.

KEY WORDS: Solar, evacuated tube, concentrator, IPH

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Passive solar refrigeration for tropical climates - state of the art review and feasibility

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31155-2-2862

STATUS: COMPLETED

CONTRACT START DATE: 83 02 28 COMPLETION DATE: 83 12 28

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CONTRACT PRICE:
$17 558

FUNDING AGENCY:
Solar Energy Program,
National Research Council
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PROJECT PRECIS:

The study was conducted to assess the feasibility of using passive solar, absorption/desorption, refrigeration cycles for short term storage of medical supplies and perishable foodstuffs at 0 to 10°C under tropical climates. The preliminary study found that such refrigeration systems using dessicant salts as storage materials and water as working fluid can be potentially cost effective when compared to other conventional refrigeration systems, especially for the removal of field heat of typical crops. Such systems will be charged during the day time by solar heat, and will be discharged at night to provide cooling. Three design concepts were envisaged including:

(i) a small cooler (225 L) for overnight storage;
(ii) a large cooler (12 600 L) for extended storage (3 to 7 days) and field heat removal; and
(iii) a mobile 3-ton trailer for extended storage and field heat removal.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A OS2. The final report will be made available July 1, 1984.

KEY WORDS: Solar, refrigeration, cooling, dessicant

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Feasibility study on significant cost reduction for industrial solar collector arrays	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-0010
STATUS: COMPLETED	
CONTRACT START DATE: 83 05 27	COMPLETION DATE: 84 05 30
CONTRACTOR: Petro-Sun International Incorporated 2290 de la Métropole Longueuil, Québec J4G 1E6	PRINCIPAL INVESTIGATOR: J. Sicotte (514) 670-8043
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: G. Yen Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $46 285	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The purpose of this work was to investigate whether significant cost reductions for industrial solar collector arrays were possible through the use of a site-uncoiled solar absorber, a light-weight support rack, and a prefabricated frame.

Computer simulation of the thermal performance of the proposed collector was carried out using different construction approaches. The collector design was optimized with regard to cost, performance, weight, durability, and ease of manufacture and installation. The potential for selectively coating continuous coils of aluminum/copper fins and recoiling them for shipment was investigated.

A single collector of up to 400 m^2 could be built using commercially available materials and normal construction methods for less than 200$/$m^2$.

The MEGA collector SUNRACK support system (an air-bag support) was integrated with the collector design.

The anticiapted installed cost was estimated to be 181$/$m^2$ and the anticipated cost of thermal performance was estimated to be $65 per annual GJ.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2. The full report will be released in January 1985.

KEY WORDS: Solar, collector array, prefabrication, support rack

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Technical and economic considerations in the use of solar as a primary energy source in Canada

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 04SX.31926-3-0021

STATUS: COMPLETED

CONTRACT START DATE: 83 07 15 COMPLETION DATE: 83 10 14

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CONTRACT PRICE:
$13 530

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT PRECIS:

In this study, the author examines the prospect of utilizing solar energy in its primary mode to meet a large part of Canada's future energy needs. The author has set down his reasons for believing that we should consider harnessing solar energy in a different way from the conventional methods. In his view the energy from the sun is of such high thermodynamic quality that, in principle, it can provide a large fraction of Canada's non-transportation energy needs - without requiring any major new scientific discoveries. For solar energy to play a major role as a primary energy source, it is essential that the solar systems provide for massive amounts of energy storage in a form that is suitable for high grade applications, such as for conversion to electricity or for use as industrial process heat.

The report addresses various aspects of the technology that would be suitable for the Canadian scene, and concludes that there are no immense technical hurdles to be overcome in the immediate development of an experimental solar primary energy system.

REPORTS AND REFERENCE SOURCES: The final report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, primary energy, system, storage

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Solar refrigeration feasibility study

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31926-3-3014

STATUS: COMPLETED

CONTRACT START DATE: 84 09 28 COMPLETION DATE: 84 05 15

CONTRACTOR:
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CONTRACT PRICE:
$11 606

FUNDING AGENCY:
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PROJECT PRECIS:

The physical feasibility of an absorption regrigeration system using solar panels was detailed by briefly investigating the thermodynamics cycle, energy delivered, preferred working fluids, and heats of vaporization. The study roughly determined the expected fluid volumes to be used in the system and their practicality in the arrangement.

The economic feasibility was investigated largely through contacts with experts in the need for storage of foodstuffs and medical supplies in the tropics.

The study concluded that a price tag of approximately $1100 Cdn. is required to produce the equivalent capacity of refrigeration of 8.4 kg of ice per day. However, the study on the payback period was based on the assumption that 365 sunny days are available in a year.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, refrigeration

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Information background for an R&D plan for commercial, institutional and industrial process solar technology	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-5019
STATUS: COMPLETED	
CONTRACT START DATE: 83 08 24	COMPLETION DATE: 84 04 02
CONTRACTOR: Marbek Resource Consultants Ltd. 2211 Riverside Drive Ottawa, Ontario K1H 7X5	PRINCIPAL INVESTIGATOR: D.B. Brooks & R. Peters (613) 523-0784
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $51 890	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this project was to identify the potential domestic markets for solar technology in the commercial, institutional, and industrial process sectors, and to develop draft research and development plans that would bring these technologies to commercial readiness.

The report provides estimates of energy requirements per unit of production or energy requirements as a fraction of the total sector after conservation and heat recovery measures have been applied. The following basic applications were identified: preheating of air and water from ambient temperatures; commercial and institutional hot water heating up to 50°C; industrial hot air or steam heating up to 250°C; industrial hot water heating up to 120°C; commercial and institutional space heating and cooling; and high temperature heat delivered above 250°C for industrial processes and/or electricity generation.

Break-even costs against currently used fuels in each basic application were determined, and cost goals for solar technology R&D, based on current costs and prospects for cost reduction, were developed. The results showed that for 3 or 4 of the basic applications, solar technology in the commercial, institutional, and industrial sectors could be competitive well before 1990. Other applications could be competitive before 2000.

R&D activities were proposed for component and system development for each application, taking into account the potential energy contribution, and the attainability of cost effectiveness for the near, intermediate, and long-term time frames.

REPORTS AND REFERENCE SOURCES: The project digest is available as report No. IPH-2-D from Publication Sales & Distribution, Bldg. R-88, Montreal Rd., Ottawa, Ontario, K1A 0R6. The digest and full report are available on loan from CISTI.

KEY WORDS: Solar, commercial, institutional, industrial, R&D Plan

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Generation of basic engineering data on zeolite storage systems

OERD REFERENCE NO: 4.2.3 **DSS FILE NO:** 04SX.31155-1-2644A

STATUS: COMPLETED

CONTRACT START DATE: 82 07 08 **COMPLETION DATE:** 83 11 23

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CONTRACT PRICE:
$67 918

FUNDING AGENCY:
Solar Energy Program,
National Research Council
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Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Zeolites are natural and synthetic minerals (composed of silica and alumina) that can be used to store thermal energy. Energy is stored in the zeolite bed when hot and dry air is passed through the bed driving off the water in the bed. Energy is released when cool and humid air is passed through the bed allowing the water to be absorbed in the bed, thus releasing the heat of condensation.

A combined theoretical and experimental approach has been taken to develop a more complete basic understanding of the behaviour of zeolites as a thermal storage medium. In the theorectical approach, an efficient computation scheme was developed to the degree that local temperature profiles can be predicted. In the experiments, two module sizes were used, and in the small module both radial flow design and axial flow design were examined.

The test results show the radial flow design produces less pronounced thermal contours in the bed than with the axial flow design. Although the theoretical predictions are in reasonably good agreement with the experiments, it appears as though the mass transfer in the pore structure of the zeolite particle may not behave quite as simply as the model portrays. Some more detailed modelling in this regard is needed to bring about better simulation of the bed behavior.

REPORTS AND REFERENCE SOURCES: This full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, zeolite, thermal storage

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of a semi-crystalline polymer as a phase-change material for solar energy storage		
OERD REFERENCE NO:	4.2.3	DSS FILE NO:	02SX.31155-1-2644D
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	82 07 08	COMPLETION DATE:	84 06 08
NEXT MILESTONE & DATE:	84 06 08		

CONTRACTOR:	PRINCIPAL INVESTIGATOR:
Ontario Hydro Research Division 800 Kipling Avenue Toronto, Ontario M8Z 5S4	David C. Cordingley (416) 231-4111
NRC PROJECT MANAGER:	NRC PROJECT SCIENTIST:
K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	D.T.L. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE:	FUNDING AGENCY:
$45 300	Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

An investigation of the potential for using low-cost polyolefin phase-change materials to store heat will be carried out.

Selected resins will be extruded or drawn out to form a structured state. The resins will then be cross-linked by irradiation from a Cobalt-60 source or by an electron beam at a controlled temperature. This process increases the degree of crystallization and hence the latent heat of fusion and it is expected that a large portion of the molecular order will be maintained throughout successive melting and recrystallization processes. These hypotheses will be tested by measurements of the heats of fusion and gel contents of original and processed resins.

KEY WORDS: Solar, storage, phase-change material, polyolefin

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Continued development of a concentrating solar collector for medium temperature applications	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31155-2-2848
STATUS: IN PROGRESS AS OF: 83 06 10	
CONTRACT START DATE: 83 03 30	COMPLETION DATE: 84 07 10
NEXT MILESTONE & DATE: 84 07 10	
CONTRACTOR: Solartech Limited 39 Cranfield Road Toronto, Ontario M4B 3H6	PRINCIPAL INVESTIGATOR: Bernard Ennis (416) 752-4990
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $58 931	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

A production prototype of a low concentration ratio east-west axis concentrating parabolic collector developed under a previous contract (DSS File no. 02SX.31155-0-2690C) is to be designed and fabricated.

Work is required on this collector designed for medium temperature applications in order to reduce costs, particularly of the reflector assembly, and to make the collector suitable for commercial production. Roll-formed framewalls are to be designed, fabricated, and tested for durability and rigidity. This is to be followed by the tooling design and the detailed design of a REFLEX™ collector utilizing roll-formed reflector cusps and framewall sections. Three production model prototypes are to be constructed and tested. One of the prototypes is to be submitted to the National Solar Test Facility for thermal performance testing. The expected cost of a production model is to be calculated and quotations obtained from tooling and material suppliers.

KEY WORDS: Solar, concentrating collector, commercialization

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of a Canadian industrial solar pond technology - Phase III: In pond testing of the pond monitoring and control system	
OERD REFERENCE NO: 4.2.3	**DSS FILE NO:** 04SX.31926-3-0040
STATUS: COMPLETED	
CONTRACT START DATE: 83 04 29	**COMPLETION DATE:** 83 10 17
CONTRACTOR: Coreco Incorporated 475 St-Charles Ouest Suite 118 Longueuil, Quebec J4X 3X1	**PRINCIPAL INVESTIGATOR:** D. Crevier (514) 651-2919
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	**NRC PROJECT SCIENTIST:** D. Colley Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $114 539	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The Phase III contract (a follow-on to two previous contracts, Nos. 0-2721E & 2-2752) was aimed at proving the viability and investigating areas of weakness in the design of the solar pond monitoring and control system.

The work carried out through this contract encompassed routine maintenance and performance monitoring of the experimental solar pond at Valcide, Quebec, fabrication and installation of the prototype monitoring and control system, and extensive testing and modification of the system. In addition, the transient simulation program developed under Phase II was documented.

A study on the applicability of solar ponds to supply industrial process heat concluded that there is significant potential for this technology in Canada. Work on the automated solar pond monitoring and control system is ongoing through a Phase IV contract.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario, K1A 0S2. The full report contains confidential information and is not for release at this time.

KEY WORDS: Solar, pond, industrial technology, monitoring, automated operation

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a Canadian solar pond technology: Phase IV

OERD REFERENCE NO:	4.2.3	DSS FILE NO:	04SX.31926-3-0108
STATUS: IN PROGRESS AS OF:	84 04 04		
CONTRACT START DATE:	83 10 27	COMPLETION DATE:	84 06 29
NEXT MILESTONE & DATE:	84 06 29		

CONTRACTOR:
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NRC PROJECT SCIENTIST:
D. Colley
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6
(613) 993-9224

CONTRACT PRICE:
$85 978

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The work to be carried out under this contract follows on from the previous three phases (see contract file no. 26-3-0040).

The Coreco solar pond monitoring and control system will be operated throughout the fall and winter, in order to detect defects in the hardware and software.

The development of the pond simulation software, started during Phase II, will be completed and integrated with the Pond Control Software in order to produce a more user-friendly pond operation package.

The design of the system, built during Phase III, will be modified to correct defects detected during the latter part of Phase III and during the first task of this contract.

KEY WORDS: Solar, pond, control, monitoring

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design of a high-temperature concentrating solar collector - Phase I	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31155-0-2690J
STATUS: COMPLETED	
CONTRACT START DATE: 81 08 12	COMPLETION DATE: 83 01 17
CONTRACTOR: Amherst Renewable Energy Limited Box 387 Perth, Ontario K7H 3G1	PRINCIPAL INVESTIGATOR: R.W. Davies (613) 820-3274
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: K.A.H. Mills Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $48 998	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The objective of this work was to design portions of a medium temperature solar collector based on the Philips VTR 141 Solar Receiver Tube, and it led to the production of the Amherst A300 evacuated-tube solar collector. Three concentrator shapes were designed: with tubular grooves, with tubular grooves and flats, and compound parabolic. The energy striking the absorber, and hence the collector performance were calculated for each shape with the help of ray tracing using manual drafting methods.

Mirror materials of two categories were investigated: solid bright, such as polished aluminum; and substrate plus surface, such as aluminum vacuum deposited on polycarbonate, or a reflective film glued to a substrate. The investigation encompassed methods of shaping, surface protection, rigidity, adhesion, reflectance, specularity, stability in the presence of ultraviolet light and weather, abrasion resistance, appearance and cost. Stetching reduces reflectivity, greatly for metallized plastics, and slightly for solid metals.

When using foils attached to a substrate, it is very difficult to eliminate creases and bubbles. Plastic substrates by themselves have insufficient structural rigidity, unless they are very thick or have ribs; metals generally have sufficient rigidity even when they are quite thin. It was found that a white diffuse reflector is durable, cheap to make, and provides a performance that is little worse than the best-shaped reflector investigated.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), national Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A OS2

KEY WORDS: Solar, collector, concentrating, absorber

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Research and development of an advanced solar collector

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31155-1-2605

STATUS: IN PROGRESS AS OF: 84 06 21

CONTRACT START DATE: 83 08 01 COMPLETION DATE: 86 04 30

NEXT MILESTONE & DATE: 84 09 28

CONTRACTOR:
Spectravac Power Conversion Systems Inc.
1520 Trinity Drive, Unit 12
Mississauga, Ontario
L5T 1L6

PRINCIPAL INVESTIGATOR:
Leo Dorbeck
(416) 676-9040

NRC PROJECT MANAGER:
K.G. Lund
Solar Energy Program
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6
(613) 993-9224

NRC PROJECT SCIENTIST:
D. Yung
Solar Energy Program
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CONTRACT PRICE:
$3 707 620

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The overall objective is to research and develop an advanced, evacuated, flat-plate, solar collector. The advanced collector is capable of delivering high temperature heat at high thermal efficiency, but is constructed with minimal material content.

The work will include the research, design, building, and testing of ten advanced, high-temperature, high-efficiency prototype solar collectors. The work is divided into twelve tasks:

1. Glass-to-metal hermetic seals
2. Cover glass and support structure
3. Vacuum retention and production
4. Thermal-optics
5. Collector body
6. Absorber
7. Fluids and flow
8. Product engineering
9. Intra-array piping
10. Collector assembly
11. Collector test
12. Industrial process heat study

KEY WORDS: Solar, evacuated, flat-plate, collector

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Investigation of stratified thermal energy storage for solar heating systems

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31155-1-2644B

STATUS: COMPLETED

CONTRACT START DATE: 83 02 25 COMPLETION DATE: 84 04 25

CONTRACTOR:
Giffels Associates Ltd.
30 International Blvd.
Rexdale, Ontario
M9W 5P3

PRINCIPAL INVESTIGATOR:
C. Lehman
(416) 675-5950

NRC PROJECT MANAGER:
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Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-9224

NRC PROJECT SCIENTIST:
D. Yung
Solar Energy Program
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CONTRACT PRICE:
$47 563

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

One control strategy to improve thermal performance of a solar heating system is to use thermal stratification. If thermal stratification can be maintained in the thermal storage tank, it allows a lower water inlet temperature into the collector and therefore a higher collector efficiency. Most previous work on thermal stratification, however, has been for vertical tanks. The present project has investigated how a large horizontal tank (10 000 L) could best be stratified by using low-flow strategy and various stratification devices.

A 454-L scale model test loop of a large horizontal tank was used to test the stratification effectiveness of: (1) a bare tank; (2) a tank with a vertical "T" diffuser; and (3) a tank with two vertical baffles. A low-flow strategy was used in the test. The WATSUN computer simulation program was modified to match the test results of each of the three test configurations. The modified WATSUN programs were then used to evaluate the cost effectiveness of each of the three stratification configurations.

The results of the computer simulations show that both the bare tank and the "T" diffuser are cost-effective; but the baffles are not cost-effective.

REPORTS AND REFERENCE SOURCES: A final report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Storage, horizontal, tank, thermal, stratification

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of an evacuated tube collector utilizing CPC reflectors and a specialized absorber fin	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31155-2-2644
STATUS: COMPLETED	
CONTRACT START DATE: 83 02 18	COMPLETION DATE: 84 06 29
CONTRACTOR: Solartech Ltd. 700 Gordon Baker Rd. Willowdale, Ontario M2H 3B4	PRINCIPAL INVESTIGATOR: B. Ennis (416) 495-1416
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $54 273	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The primary aim of this project was to develop an evacuated tube collector (ETC) which would utilize a Reflex™ enhanced absorption fin. The secondary aims were to develop a collector which:

1. eliminates the flow problems associated with the 1st generation ETC;
2. is less expensive than the 1st generation ETC;
3. has a higher thermal performance than the 1st generation ETC.

The new design incorporates a glass U-tube flow path to which an extruded aluminum Reflex™ absorber fin is attached. This fin-tube assembly is inserted into a larger diameter glass envelope tube which is subsequently evacuated and sealed. A dual header concept is used to connect the U-tube risers. The eight outer tubes in the design are mounted within compound parabolic cusp reflectors of tri-laminate material comprising Tedlar™, aluminized mylar, and aluminum sheet.

The contractor claims that a 35% increase in peak efficiency was achieved over the previous ETC design, resulting in a substantial improvement in annual system operating performance. According to f-chart simulations for domestic hot water systems, the predicted Reflex™ ETC performance is 3.30 GJ/m^2.a (compared to 2.19 GJ/m^2.a for the 1st generation ETC). The cost reduction achieved with the new design has resulted in the following improvement in the installed cost/performance ratio:

Reflex™ ETC: 307.91$/(GJ/a)
1st generation ETC: 372.00$/(GJ/a).

REPORTS AND REFERENCE SOURCES: Project digest and final report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, collector, evacuated tube, Reflex™, concentrating

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: The design and development of improved solar panel connectors	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-0009
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 06 07	COMPLETION DATE: 84 06 01
NEXT MILESTONE & DATE: 84 06 01	
CONTRACTOR: Nortec Solar Industries Incorporated P.O. Box 288, Century Road Manotick, Ontario K0A 2N0	PRINCIPAL INVESTIGATOR: James B. Ramsden (613) 692-2513
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D.T.L. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $42 283	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Improved couplings to connect solar collectors are to be designed. These couplings are to be reliable, easily installed, tolerant of expansion and contraction, low cost, and space saving.

The design parameters are to be quantified in consultation with existing users. A laboratory program is to be defined to test the connectors at the extremes of temperatures found in solar collectors. The contractor is to make recommendations for future work including the advisability of building and testing prototype units.

KEY WORDS: Solar, collector, connectors

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a header to solve flow distribution problems in solar collector systems

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31926-3-0014

STATUS: IN PROGRESS AS OF: 83 08 30

CONTRACT START DATE: 83 05 12 COMPLETION DATE: 84 07 15

NEXT MILESTONE & DATE: 84 07 15

CONTRACTOR:
Dynaflo Solar Incorporated
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Montreal, Québec H3G 1R4

PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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(613) 993-9224

NRC PROJECT SCIENTIST:
Paul Sparrow
Solar Energy Program
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(613) 993-9224

CONTRACT PRICE:
$55 737

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A single header for all liquid flat plate solar collectors is to be developed to overcome the piping cost problems and flow distribution problems normally encountered in medium and large closed-loop and drumback systems.

This header concept depends on a combination of Pitot effect and ejector effect so that the fluid flow in collector risers depends on the velocity head rather than the static head, and thus is more easily controlled.

A transparent prototype header is to be designed, built, tested, and modified as necessary. Calculations of the flow characteristics are to be made and further prototypes with different inlet and outlet configurations developed. A study of material and labour optimization is to be carried out to determine proper production and assembly methods.

KEY WORDS: Solar, collector, header, flow distribution

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Thermal diode collector R&D. Phase II, Part B

OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-0110
STATUS: IN PROGRESS AS OF: 84 04 26	
CONTRACT START DATE: 84 02 09	COMPLETION DATE: 85 03 19
NEXT MILESTONE & DATE: 85 03 19	

CONTRACTOR: Norsun P.O. Box 760 Manotick, Ontario K0A 2N0	PRINCIPAL INVESTIGATOR: J. Ramsden (613) 692-2513
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $111 364	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The overall objective is to construct a computer code which can be used as a design tool for the thermal diode collector. The immediate objective is to understand the basic heat transfer mechanism of the Norsun collector, and to generate a correlation, or a physical model, which can be used as input to the computer code. In addition, the contractor wants to improve some features of the collector so that it can be sold in California and Florida.

Visual observations of the boiling and condensing processes occurring inside the collector will be made using a glass rig. Enhancement tests will be performed and a literature survey carried out followed by the generation of a correlation or physical model for the mechanisms.

Additionally a vented double-wall heat exchanger and a high-wind-load solar collector will be built and tested. The causes of collector freezing, will be determined and remedies developed.

KEY WORDS: Solar, collector, thermal diode, wind, freezing

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of a convection barrier for performance improvement of solar collectors	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31926-3-3005
STATUS: IN PROGRESS AS OF: 84 05 09	
CONTRACT START DATE: 83 11 30	COMPLETION DATE: 84 06 30
NEXT MILESTONE & DATE: 84 06 30	
CONTRACTOR: Petro-Sun International Inc. 2290 de la Métropole Longueuil, Québec J4G 1E6	PRINCIPAL INVESTIGATOR: D.S. Halme (514) 670-8043
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $27 545	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The use of silica aerogel as a convection barrier in flat plate solar collectors is to be investigated.

Various convection barriers have been proposed to reduce losses so that flat plate collectors can compete in the higher temperature applications such as industrial process heat and space cooling. One such material, silica aerogel, is still in the preliminary development stage, and further work is required before its full market potential can be assessed. The vital statistics of aerogel and the design parameters for a collector are to be determined after which two prototype collectors will be built and testing carried out at Institut national de la recherche scientifique.

KEY WORDS: Solar, collector, insulation, aerogel

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: The development of a second generation air collector system for industrial walls	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-3013
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 09 30	COMPLETION DATE: 84 09 20
NEXT MILESTONE & DATE: 84 09 20	

CONTRACTOR: Watershed Energy Systems Ltd. 97 Six Point Road Toronto, Ontario M8Z 2X3	PRINCIPAL INVESTIGATOR: D. Hart (416) 233-3241
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: G. Yen Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $62 525	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The contractor will produce detailed working drawings complete with full pricing and estimates of installation costs for a new air collector. The prototype must meet an installed system cost of 150$/$m^2$ or less, and have a cost/performance ratio (including conservation) of 75$/GJ. A prototype will be produced for performance testing at the National Solar Test Facility.

KEY WORDS: Solar, collector, air, wall

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Refinement of the cylindrical parabolic solar collector

OERD REFERENCE NO: 4.2.3 **DSS FILE NO:** 02SX.31926-3-3015

STATUS: COMPLETED

CONTRACT START DATE: 83 08 05 **COMPLETION DATE:** 84 06 08

CONTRACTOR:
Asecor Ltd.
Box 929
Manotick, Ontario
K0A 2N0

PRINCIPAL INVESTIGATOR:
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(613) 692-4495

NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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Solar Energy Program
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(613) 993-9224

CONTRACT PRICE:
$24 027

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

This project was carried out by Asecor to seek improvements in production cost and in performance and reliability of their cylindrical parabolic solar collector. Results of their work show:

(1) For the absorber design, an aluminum pipe with a selective paint finish is more cost effective than a steel pipe with a black nickel finish.

(2) A new design for the end support that uses less material has been developed.

(3) An open loop, no feedback, tracking system has been developed and tested.

(4) For the mirror support, a rivetted aluminum assembly is more cost effective than a spot-welded steel assembly.

(5) A better reflecting surface is achieved by using a thin glass laminate mirror than by the polished aluminum used earlier.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2. The full report is not currently available.

KEY WORDS: Solar, collector, parabolic

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Series and parallel arrangements of the Bubble Pump

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 04SX.31926-3-3040

STATUS: COMPLETED

CONTRACT START DATE: 83 09 30 COMPLETION DATE: 84 05 14

CONTRACTOR:
Bubble Action Pumps Ltd.
2 Cataraqui Street
Kingston, Ontario
K7K 1Z7

PRINCIPAL INVESTIGATOR:
Wilfred Sorensen
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$21 507

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The bubble pump is a self-pumping device that derives its pump head from the bubbles generated within the boiling tubes as a result of solar heating. In solar hot water applications, this device can provide self-regulated pumping without the use of mechanical pumps and controllers. The object of this study is to experimentally investigate the operational characteristics of these pumps when they are connected in series or in parallel.

The operational characteristics were obtained with one to four such devices connected either in series or in parallel, and for two inlet water temperatures, four heating levels, and three flow restrictions. Contrary to previous theorectical predictions, the results show the parallel arrangement in general gives better performance than the series arrangement.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library) National Research Council, Building R-105, Ottawa, Ontario K1A 0S2. A final report will be available March 1985.

KEY WORDS: Solar, bubble pump, series, parallel

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Research and development of a low ratio linear concentrating solar collector. Phase III		
OERD REFERENCE NO:	4.2.3	DSS FILE NO:	04SX.31926-3-3043
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 12 29	COMPLETION DATE:	84 07 02
NEXT MILESTONE & DATE:	84 07 02		

CONTRACTOR:
SolWay Energy Corporation
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V6P 5Z2

PRINCIPAL INVESTIGATOR:
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(604) 324-3327

NRC PROJECT MANAGER:
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Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-9224

NRC PROJECT SCIENTIST:
P. Sparrow
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-9224

CONTRACT PRICE:
$49 995

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

This contract completes a three phase development project. Theoretical considerations were accounted for in Phase I, and a full size prototype test model developed and tested in Phase II.

Phase III deals with:

(a) Development of a proposed low cost method to manufacture the curve profile.
(b) Experimentation with various methods of reducing internal convection losses and with higher concentration ratios to increase thermal performance at higher temperatures.
(c) Comparative thermal testing by B.C. Research using a reference collector tested at National Solar Test Facility under Phase II.

KEY WORDS: Solar, collector, fixed concentrator

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of an integrated solar energy collection storage and distribution packaged system	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31155-0-2615
STATUS: COMPLETED	
CONTRACT START DATE: 80 11 17	COMPLETION DATE: 84 04 30
CONTRACTOR: Solatherm Envirotron 2600 Drew Road Mississauga, Ontario L4T 3M5	PRINCIPAL INVESTIGATOR: B. Chan (416) 677-1020
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $96 912	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

This project concerns the development of a packaged modular solar heat collection, storage, and distribution system. The short term heat storage component utilizes water as a phase change medium in conjunction with an ice-making heat pump.

This project is a continuation of an earlier project done by Solatherm (DSS Contract File No. 02SX.31155-8-2657). The previous work resulted in the building of a proof-of-concept ice generating heat pump system for storing solar heat, and is described in SEP Report No. STOR-7.

The objective of the work in this follow-on contract was to refine the system components, and to address the problems identified in the previous project, namely: snow and frost build-up on the collectors, poor level of performance of the heat pump due to low evaporator temperatures, and poor evaporator performance. The system components were refined, a new prototype system was built and tested, and a comprehensive computer simulation package was developed. The following advantages of an ice storage solar system over conventional solar systems were confirmed:

1) a much smaller storage tank can be utilized
2) lower cost, medium to low temperature collectors may be used, resulting in a lower total system cost
3) collectors operate at a higher efficiency level than those in a conventional system, due to their lower average operating temperature.
4) since ice storage solar systems use an electrically powered heat pump, they are usually cheaper to operate than solar systems which rely upon other heating fuels for their backup.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R 105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, heating, heat pump, storage, commercial

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: A project to develop pre-engineered modular solar IPH systems

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31155-2-2849

STATUS: COMPLETED

CONTRACT START DATE: 83 03 30 COMPLETION DATE: 84 02 07

CONTRACTOR:
General Solar Inc.
99 Bruce Crescent
Carleton Place, Ontario
K7C 3P4

PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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(613) 993-9224

NRC PROJECT SCIENTIST:
G. Yen
Solar Energy Program
Bldg. R-92, Montreal Road
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CONTRACT PRICE:
$65 000

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this work was to develop a series of pre-engineered solar industrial process heating (IPH) systems which could be installed for a maximum of 40$/(GJ/a) and which will have a minimum useful life of 20 years.

However, only one self-supporting collector module was designed and suitable materials determined for its construction. An investigation of appropriate support systems for either roof or ground mounting was carried out. Low-cost devices for interconnecting the collector manifolds to permit close mounting of the absorbers were designed but remained to be proven by testing.

Those, who are interested in the solar collector, should read the report with DSS file no. 02SX.31926-3-0083, which gives the detailed design.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, IPH, system design

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Parametric design optimization of a solar power, air cooled system for absorption air conditioning/refrigeration	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-3003
STATUS: IN PROGRESS AS OF: 83 11 22	
CONTRACT START DATE: 83 11 04	COMPLETION DATE: 84 07 24
NEXT MILESTONE & DATE: 84 07 24	

CONTRACTOR: Asecor Ltd. Box 929 Manotick, Ontario K0A 2N0	PRINCIPAL INVESTIGATOR: E. Plett (613) 692-4495
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $40 886	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A solar absorption air-conditioning/refrigeration system is to be developed for small scale (1 ton or less) air-cooled applications. Using theoretical modelling coupled with experimentation the contractor is to develop specific design guidelines and recommend whether or not a prototype unit should be built.

Data on refrigerant/absorbent combinations are to be compiled and thermodynamic and heat transfer steady state analysis performed to select component sizes for subsequent dynamic simulation. A variational study on the sizes of these components will also be conducted in the simulation. Mock-ups of a generator-condenser and an absorber are to be designed, built, and tested and the parametric design finalized.

KEY WORDS: Solar, absorption, air conditioning, refrigeration

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Optimizing the performance of a solar liquid piston pump

OERD REFERENCE NO: 4.2.1 DSS FILE NO: 02SX.31926-3-3004

STATUS: IN PROGRESS AS OF: 83 08 23

CONTRACT START DATE: 83 07 01 COMPLETION DATE: 84 10 31

NEXT MILESTONE & DATE: 84 10 31

CONTRACTOR:
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Office of Industrial Research
Dawson Hall, 853 Sherboooke St. West
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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(613) 993-9224

CONTRACT PRICE:
$33 874

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Further development work is to be carried out on the "Solar Liquid Piston Pump" (SLPP).

This single and inexpensive pump has good potential for pumping water in hot arid regions of the world. However, the efficiency of these pumps is still low and further work is required before its full market potential can be assessed.

The computer model of the SLPP will be improved and the optimum performance of the pump determined. Two of the pumps will be connected in series to determine what are the effects of scale on pump operation. A full-scale SLPP will be designed, built, and tested incorporating any modifications deemed necessary.

KEY WORDS: Solar, pump, performance

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Perfecting the thermal diode collector and system use. Phase II, Part A	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-3008
STATUS: IN PROGRESS AS OF: 83 11 23	
CONTRACT START DATE: 83 11 04	COMPLETION DATE: 84 12 28
NEXT MILESTONE & DATE: 84 12 28	
CONTRACTOR: Norsun A Division of Nortec Solar Ind. Inc. P.O. Box 760 Manotick, Ontario K0A 2N0	PRINCIPAL INVESTIGATOR: J. Ramsden (613) 692-2513
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: D. Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $73 278	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The overall aim of this work is the reduction in cost of the thermal diode collector system; the specific objectives are to improve system performance, to reduce installation costs, and to seek better methods of freeze protection.

In Phase I of this work (DSS File No. 02SX.31155-2-2617) the contractor carried out system performance studies of seven system configurations and experimental tests of a thermosyphon freeze protection system. All seven systems worked equally well, but the freeze protection system did not.

Two single-tank timer-controlled closed-loop antifreeze systems will be built and instrumented, one to use low flow, the other high flow. The performance of these systems will be compared with the conventional one. A closed-loop drain-back system for freeze protection of the thermal diode collector system will be designed. It is anticipated that installation costs for collectors could be reduced in new-home construction by the development of a collector which can be mounted flat with the roof. A prototype collector/mounting system for this type of installation will be designed.

KEY WORDS: Solar, collector, thermal diode, heating

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Design study for multi-collector industrial process heating systems

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 04SX.31926-3-3007

STATUS: IN PROGRESS AS OF: 84 04 30

CONTRACT START DATE: 83 09 12 COMPLETION DATE: 84 06 30

NEXT MILESTONE & DATE: 84 06 30

CONTRACTOR:
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Ottawa, Ontario
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PRINCIPAL INVESTIGATOR:
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(613) 746-3760

NRC PROJECT MANAGER:
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Ottawa, Ontario, K1A 0R6
(613) 993-9224

NRC PROJECT SCIENTIST:
W.E. Carscallen
Solar Energy Program
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(613) 993-9224

CONTRACT PRICE:
$34 265

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A study will be performed to assess the feasibility of using several different collector types in one industrial process heating system. A second objective is the preparation of general design guidelines to narrow the scope of variables involved in designing large IPH systems.

Plastic, flat plate, and concentrating collectors operating individually or in series will be modelled and the thermal performances of various system configurations will be compared. Loads, flows, control strategies and layouts will be analyzed and the costs of various schemes estimated. WATSUN-III runs will be performed to assess the annual and economic performances.

KEY WORDS: Solar, IPH, industrial, process heat, design guidelines, WATSUN

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Level B monitoring of the solar system at Applewood School, St. Catharines	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31155-0-2681
STATUS: COMPLETED	
CONTRACT START DATE: 81 09 15	COMPLETION DATE: 83 09 15
CONTRACTOR: Ontario Research Foundation Sheridan Park Mississauga, Ontario L5K 1B3	PRINCIPAL INVESTIGATOR: J. Larocque (416) 822-4111
NRC PROJECT MANAGER: T. LeFeuvre Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: T. Onno Solar Energy Program, Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6 (613) 993-3405
CONTRACT PRICE: $55 678	FUNDING AGENCY: Solar Energy Program, National Research Council Bldg. R-92, Montreal Road, Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Level B monitoring was carried out on the solar system at Applewood School, St. Catharines, Ontario to obtain monthly performance data.

The MATER data acquisition system which was installed includes specialized circuitry to accommodate the solar assisted heat pump system at the school. A display panel to indicate primary energy and temperature parameters was also installed.

The data generated shows an average solar collector efficiency of 29.7% and overall solar system efficiency of 23.1% (figures based on data from the monitoring period: June 1st, 1982 to December 31st, 1982 for which complete data is available). The solar system and reclaimed excess building heat provided 100% of the building's heating needs during the monitoring period from June 1, 1982 to April 30, 1983, approximately 86% of which can be attributed to strictly solar sources.

REPORTS AND REFERENCE SOURCES: The final contract report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, monitoring, space heating, domestic hot water, heat pump

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Mountain Spring, International Energy Agency (IEA) Task VI, solar energy monitoring project

OERD REFERENCE NO: 4.2.3. DSS FILE NO: 09SX.31155-0-2694

STATUS: COMPLETED

CONTRACT START DATE: 81 04 23 COMPLETION DATE: 83 12 19

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
W.E. Carscallen,
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Ottawa, Ontario, K1A OR6
(613) 993-9224

CONTRACT PRICE:
$447 113

FUNDING AGENCY:
Solar Energy Program,
National Research Council,
Bldg. 92, Montreal Rd.,
Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

The Mountain Spring project was conceived and constructed under Phase III of the System Trials and Monitoring Program of the Solar Energy Program. The solar system installed in this bottling plant in Edmonton, Alberta, was designed to assist in maintaining at a temperature of 65°C, a caustic soda solution used for the washing of empty soft drink bottles.

Evacuated tubular collectors (ETC) manufactured by Solartech present an aperture of 281 m^2 and operate in drain back mode. Energy is transferred from the solar loop to the caustic loop by standard industrial heat exchangers. Areas of investigation included: identification of problems; collection of performance data including the effects of piping thermal capacitance and collector operating mode (batch vs. continuous on); and determination of optimum system control strategy and areas of increased cost effectiveness.

Results to date have shown that the ETC Solartech system in Edmonton produces very small quantities of energy from November through Janary. The performance from November through March is significantly diminished by snow accumulation on the evacuated tube collectors. The high-temperature application and the use of black-iron have made the capacitance effects of the piping significatn in this installation. Special attention to piping runs and the use of copper is recommended for future projects in this nature.

REPORTS AND REFERENCE SOURCES:

The reports from this work have been synthesized into a paper "Performance and operation of a drain back evacuated tubular collector array at the Mountain Spring Bottle Washing Facility" by W.E. Carscallen, M. Chandrashekar, H. Taube, and H.G. Okrafka which was presented at the International Energy Agency "Workshop on the Design & Performance of Large Solar Thermal Collector Arrays". San Diego, California June 10-14, 1984. (Proceedings to be published)

KEY WORDS: Solar, IEA Task VI, monitoring

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Testing and monitoring program for solar heated water storage tanks for fire protection systems

OERD REFERENCE NO: 4.2.3 **DSS FILE NO:** 02SX.31155-0-2721G

STATUS: COMPLETED

CONTRACT START DATE: 82 03 24 **COMPLETION DATE:** 84 02 28

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
P. Sparrow
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CONTRACT PRICE:
$77 539

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The objective of this contract was to design, construct, and monitor a passive solar collection and insulation system for an existing 1 900 00 L (500 000 US gal) water storage tank used for fire protection at the Ford Motor Company of Canada in Oakville, Ontario.

The performance of the system was monitored over a 12-month period. Weekly readings showed that the water temperature in the tank was maintained well above the level at which auxiliary heating would be required. A comparison of the monitored data with that simulated by the computer simulation program proved the validity of the program.

The report concluded that the concept of solar heating large water storage tanks used for fire protection systems is practical, and that compared with a conventional tank with a fossil fired boiler heating system, a solar heated tank with an electric backup system is likely to have a lower or equal total capital cost.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, water storage tanks, freeze protection

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Computer simulation model for Mountain Spring Project and IEA Task VI

OERD REFERENCE NO: 4.2.3. DSS FILE NO: 05SX.31155-2-2784

STATUS: COMPLETED

CONTRACT START DATE: 82 11 12 COMPLETION DATE: 84 01 05

CONTRACTOR:
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Waterloo, Ontario
N2L 2W4

PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
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CONTRACT PRICE:
$52 465

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

A computer simulation modelling project was undertaken in order to better understand the simulation and system requirements for solar assisted industrial process heating systems.

The work was primarily concerned with TRNSYS simulations of the operation of the Mountain Spring bottling plant in Edmonton, Alberta and was divided into three stages:

Stage I: Refinment of the TRNSYS simulation model and review of IEA Task VI Reporting Format Document;
Stage II: Comparison of the simulated and actual results from the Mountain Spring Project; and
Stage III: Review of evacuated-tube-collector models and development of an appropriate collector array model for Solartech collectors.

Refinement of the simulation model included the writing of seven subroutines including one for evacuated tube collectors. These are described in the Stage I report. The results from the simulations (reported in the Stage II report) appear to be quite satisfactory although there is considerable room for improvement. The Stage III report summarizes the first two and reports the information contained in the literature which will assist in modelling the Mountain Spring plant.

REPORTS AND REFERENCE SOURCES: The project digest and the full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A OS2. The results were also presented at several experts meetings of the International Energy Agency Task VI.

KEY WORDS: Solar, simulation, evacuated-tube collectors, industrial process heat

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Monitoring of solar system at Les Transports Provost Inc.

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 04SX.31155-2-2786

STATUS: COMPLETED

CONTRACT START DATE: 83 07 06 COMPLETION DATE: 84 05 15

CONTRACTOR:
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
W.E. Carscallen
Solar Energy Program,
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(613) 993-9224

CONTRACT PRICE:
$203 000

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:
The thermal performance of the solar energy system at Les Transports Provost Inc. has been evaluated. The report addresses the design and installation of a monitoring system, commissioning, maintanance, and upgrading of the solar energy system, and data analysis.

The 245 flat plate collectors in this drain-back system at the tank truck washing facility provide a net operture area of 497 m^2. The array is tilted at 48° and faces due south. The preheated water is stored in a 19 125-L tank and then heated to 64°C by a gas-fired boiler.

The monitoring system, a computer-based data acquisition system recorded data from 63 channels at 5-min intervals over the 3-month monitoring period. The high collector efficiency (45% total, 57% collector "on") was attributed to low collector operating temperatures. Storage tank thermal losses were shown to be less (3.7%) since a large portion of solar energy transferred to storage was directly utilized by the load on the same day. However the actual delivered energy (238 GJ) was considerably lower than the design value of 327 GJ. Inaccurate design information led to a predicted solar fraction of 44% compared to the actual value of 21%. The economic analysis of this site yielded a cost of 20$/GJ for the delivered solar energy.

The major conclusion of this study is that industrial processes using large volumes of low to medium temperature water (60°C) are excellent prospects for future flat plate solar systems. With the reduction in cost and slight increase in collected energy expected with the new larger area collectors, such a system could be cost competitive with natural gas at 10$/GJ.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Solar, IPH, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Mountain Spring, IEA Task VI, Solar Energy Monitoring Project: Part II	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 01SX.31926-3-0042
STATUS: IN PROGRESS AS OF: 83 08 30	
CONTRACT START DATE: 83 06 22	COMPLETION DATE: 85 05 31
NEXT MILESTONE & DATE: 85 05 31	
CONTRACTOR: MacLaren Plansearch Inc. 10240-124 Street Edmonton, Alberta T5N 3W6	PRINCIPAL INVESTIGATOR: H. Taube (403) 482-7341
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: W.E. Carscallen Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $399 460	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The contractor shall provide services which will ensure that Canada, through NRC (SEP) effectively responds to its research responsibilities in IEA Task VI. The contractor will support, advise, and assist NRC (SEP) in its research role as participant in Task VI.

The reports on the data acquisition and monitoring procedures submitted under a previous contract (09SX.31155-0-2694) are to be updated as changes are made. Periodic testing, maintenance, and calibration of the monitoring system will be carried out to ensure that the solar energy system (SES) and the monitoring system remain in an operational state for the duration of the monitoring period and in order to optimize the SES performance. Data recording and reduction will be performed until such time as sufficient data have been obtained to fully characterize the system. At this point the contractor is to remove the monitoring equipment.

A number of studies are also to be carried out including:

- an optimization study to determine which strategies would produce cost reductions in similar systems;
- a cost-effectiveness study to recommend what alterations should be implemented in the Mountain Spring system;
- a sensitivity study to determine the effect of system optimization strategies and their cost effectiveness; and
- a study to determine the durability of the system components.

KEY WORDS: Solar, IPH, IEA, Task VI

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Removal of monitoring equipment from selected field trial sites	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31926-3-0072
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 07 28	COMPLETION DATE: 84 11 01
NEXT MILESTONE & DATE: 84 11 01	
CONTRACTOR: Buchan, Lawton and Parent 5370 Canotek Road Ottawa, Ontario K1J 8X7	PRINCIPAL INVESTIGATOR: D. Buchan (613) 748-3762
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: W.E. Carscallen Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $23 216	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A number of Phase II/III solar energy systems were monitored and upgraded by W.L. Wardrop under contracts 9-2604, 0-2709, and 0-2663. In order to pursue system analysis at other sites there is a requirement for the return of the installed monitoring instrumentation.

Buchan, Lawton and Parent are to remove this equipment from seven sites after preparing a report on the status of each system. Where minor adjustments to the system are warranted to improve the operational status, these shall be performed.

KEY WORDS: Solar, monitoring, industrial, institutional, commercial

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Operational and performance monitoring of the New Delhi, India, Canadian High Commission solar pool heating and air conditioning system

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31926-3-0123

STATUS: IN PROGRESS AS OF: 84 04 30

CONTRACT START DATE: 84 02 01 COMPLETION DATE: 86 07 31

NEXT MILESTONE & DATE: 86 07 31

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CONTRACT PRICE:
$44 387

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT OBJECTIVE AND DESCRIPTION:

The solar pool heating and air conditioning system, installed in the Canadian High Commission in New Delhi, India by the Department of External Affairs of the Canadian Government in Ottawa, Canada, is to be monitored for two years.

The monitoring equipment is to be supplied by the Canadian Federal department of External Affairs. The report from this contract is to contain the system description, and details of the installation and commissioning.

The system performance is to be analyzed and compared to the expected and simulated system performance data. Experiences of system monitoring and system operation, including system downtime, maintenance time, nature of accidents, problems and lessons are to be recorded.

KEY WORDS: Solar, monitoring, pool, air conditioning

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Demonstration of a solar lighting system using a prism light guide	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31926-3-3002
STATUS: IN PROGRESS AS OF: 83 12 14	
CONTRACT START DATE: 83 09 30	COMPLETION DATE: 84 07 31
NEXT MILESTONE & DATE: 84 07 31	
CONTRACTOR: TIR Systems Ltd. 2227 Quebec St. Vancouver, B.C. V5T 3A1	PRINCIPAL INVESTIGATOR: Lorne A. Whitehead (604) 873-1683
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $67 121	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Two prototype solar lighting systems will be designed, installed, and tested to determine their operating and aging characteristics. The potential viability of future solar lighting applications will be assessed.

Each prototype solar lighting system is comprised of 1 m^2 tracking heliostat, a 1 kW metal halide electric supplemental lamp, and a prism light guide 8-m long. Photometric tests will be conducted on one system installed in Vancouver, B.C., and on one system installed on NRC property in Ottawa, Ontario.

KEY WORDS: Solar lighting system, light pipe, prism light guide

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Solar source heat pump cost-performance optimization and field trials	
OERD REFERENCE NO: 4.2.3	DSS FILE NO: 02SX.31926-3-3006
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 09 20	COMPLETION DATE: 84 05 30
NEXT MILESTONE & DATE: 84 05 30	
CONTRACTOR: B.A. Tripp & Associates Ltd. 23 Robb Blvd., Unit 1 Orangeville, Ontario L9W 3L1	PRINCIPAL INVESTIGATOR: Ben Tripp (519) 941-4651
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: David Yung Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $92 653	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The overall objective is to develop solar heating using a solar source heat pump coupled with seasonal ice storage. The immediate objective is to develop the required storage tank and heat exchanger for such a system.

Experimental tests will be carried out to obtain performance characteristics of plastic heat exchangers and to show how the performance is affected by various parameters. A theoretical model will be developed for comparison with test results.

Stress parameters for the storage tank will be determined and materials for its construction evaluated. Two medium-sized tanks will be constructed and mechanical and thermal tests performed on them. Three prototypes (10 m^3, 20 m^3, 40 m^3) will be constructed for production and freeze-thaw evaluations.

KEY WORDS: Solar, seasonal ice storage, heat pump

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Computer simulation model for Mountain Spring Project and IEA Task VI - Phase II		
OERD REFERENCE NO:	4.2.3	DSS FILE NO:	04SX.31926-3-5029
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	83 12 05	COMPLETION DATE:	84 11 30
NEXT MILESTONE & DATE:	84 11 30		

CONTRACTOR:	PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:	**NRC PROJECT SCIENTIST:**
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CONTRACT PRICE:	**FUNDING AGENCY:**
$59 260	Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Further simulations of the Mountain Spring project using both WATSUN and TRNSYS are to be carried out in preparation for the upcoming IEA Task VI meetings.

This involves carrying out optimization studies of Mountain Spring (storage size, load profiles, collector type, pipe capacitance, etc.). WATSUN simulations of evacuated-tube and flat-plate domestic hot water systems will be carried out for comparison to systems from other Task VI installations.

Included in the TRNSYS simulations of Mountain Spring will be a model of the drainback, a new model of the evacuated tube collector, refinements to account for differences in storage temperature on weekends, etc. Simplified simulation methods based on I/O will be compared to operating curves, Q-method, and WATSUN. If necessary, WATSUN IPH, DHW will be upgraded to take into account the finding of these studies.

KEY WORDS: Solar, IPH, Mountain Spring, WATSUN, simulation, IEA

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Adaptation of microcomputer energy meter to Level "A" monitoring and on-site Figure of Merit display	
OERD REFERENCE NO: 4.2.3.	DSS FILE NO: 01SX.31155-1-2635A
STATUS: COMPLETED	
CONTRACT START DATE: 82 11 01	COMPLETION DATE: 84 03 26
CONTRACTOR: Ontario Research Foundation Sheridan Park Research Community Mississauga, Ontario L5K 1B3	PRINCIPAL INVESTIGATOR: John Savage (416) 822-4111
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: W.E. Carscallen Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $53 629	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

This report describes the aims, installation, operation, and fabrication of a solar collection and utilization monitor that has been developed.

This device is capable of monitoring both energy collection, energy utilization, and the calculation of various system parameters, in this case figure of merit. The figure of merit is defined as the ratio of system actual performance in terms of energy collected to system ideal performance. It is calculated by a mathematical model which predicts theoretical system performance under the operating conditions being experienced and compares it to the actual performance in terms of energy collected. The figure of merit can be computed on a 5-min, 1-h, or 24-h basis and appears on a liquid crystal display.

The final report contains technical descriptions, block diagrams, blue prints, and software listings to be used in the manufacture of the monitor. A call for tenders to manufacture the instrument will be made shortly.

REPORTS AND REFERENCE SOURCES: Since the report contains technical specifications for the manufacture of the monitor, it is not for general release.

KEY WORDS: Solar, monitoring, energy meter, figure of merit

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Design and installation of low temperature IPH system

OERD REFERENCE NO: 4.2.3 DSS FILE NO: 02SX.31926-3-0083

STATUS: IN PROGRESS AS OF: 84 05 29

CONTRACT START DATE: 83 07 28 COMPLETION DATE: 84 09 30

NEXT MILESTONE & DATE: 84 09 30

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CONTRACT PRICE:
$99 160

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The NRC Solar Energy Program placed a contract with General Solar Inc. to design and build a scaled-down solar system with two complete modules and associated ancillary equipment at the new NRC commercial industrial process heating test facility (building M-48) in order to provide data on:

1. the cost of the solar system;
2. the durability and reliability of the solar system;
3. the thermal performance of the solar system.

The two-module solar system was erected in December 1983, but was not put into operation due to the lack of electrical power. As a result, it was allowed to stagnate throughout the winter months (i.e. December 1983 to April 1984). During this period, it was noted that snow and ice accumulated at the bottom portion of the collector.

On April 6th, 1984, it was observed that the collector frames were deformed. The company was notified and corrective actions have been taken. The system has not yet been commissioned.

KEY WORDS: Solar, system, industrial, design

PHOTOVOLTAICS

SECTION D

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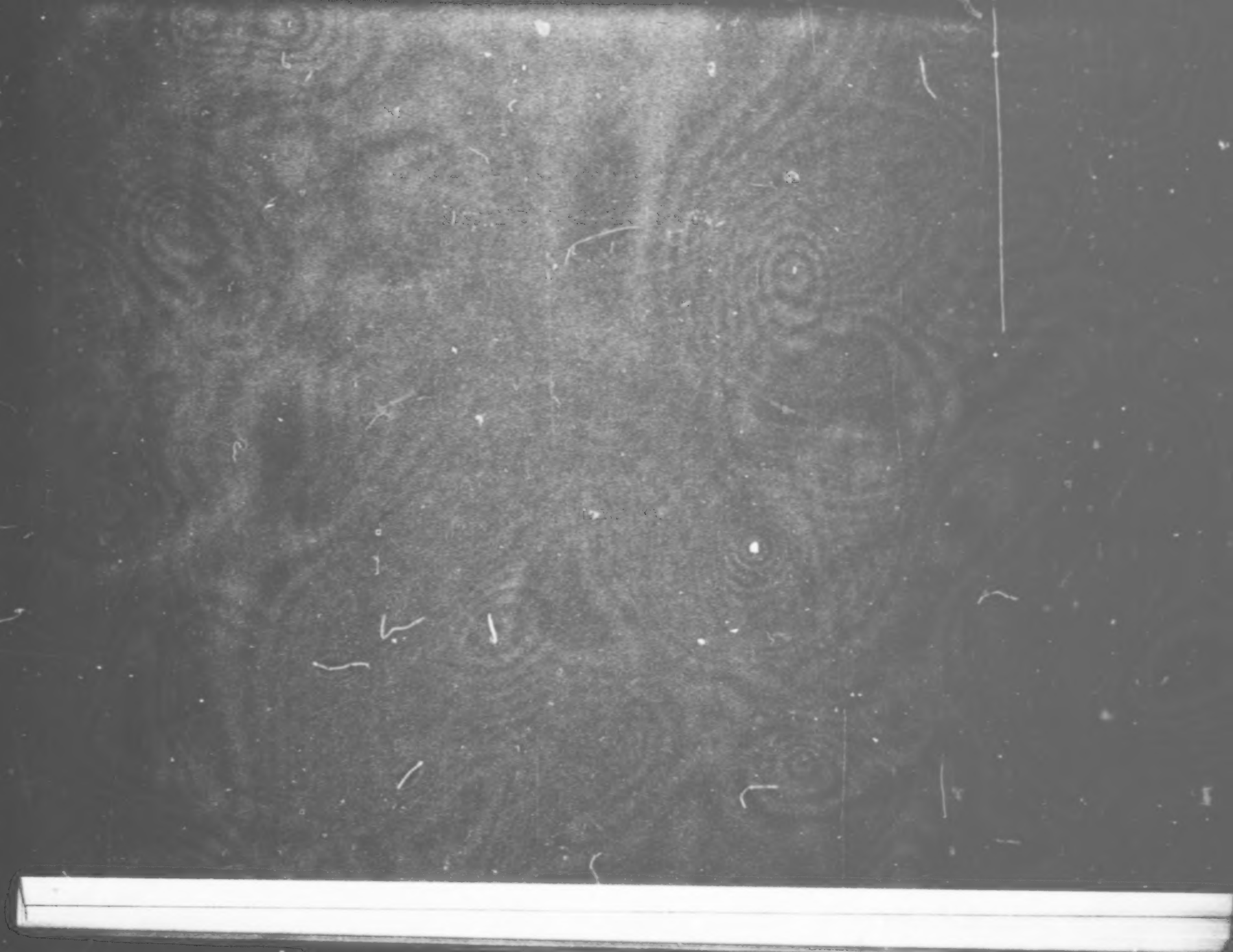

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Thin film solar cells based on ternary and higher order chalcopyrite semi-conductors

OERD REFERENCE NO: 4.2.4 DSS FILE NO: 02SX.31155-1-2613A

STATUS: COMPLETED

CONTRACT START DATE: 81 10 08 COMPLETION DATE: 84 03 07

CONTRACTOR:
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CONTRACT PRICE:
$135 480

FUNDING AGENCY:
Solar Energy Program
National Research Council
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PROJECT PRECIS:

The long term objective of this work was the development of a thin-film solar cell of at least 10% conversion efficiency in AM1 sunlight, having the potential to delivery power at 10 cents per peak watt and having a lifetime stability of at least 20 years. The approach was to examine I-III-VI_2 ternary compounds and alloy mixtures of these ternaries so as to tailor a semi-conductor material with a band gap close to optimium (1.5 eV) and lattice constant matched to CdS. Only production methods which are basically low cost were considered and in particular the work concentrated on the use of recrystallized powders and spray pyrolysis.

Although the recrystallized powder technique in the form of its screen printing variation has been successfully used elsewhere, degradation problems were encountered in this work and so the project was rescheduled to emphasize the spray pyrolysis method. A 6.5% efficient CdS on $CuInSe_2$ cell and a 4% CdS on CdTe cell were both achieved in all-spray configurations on glass substrates. Optimization of the technique including chemistry of the spray solution, atomization process, ambient and substrate temperatures, type of substrate, and effects of dopants and impurities was carried out. It was found that the pH of the spray solution was critical to the formation of the chalcopyrite phase.

REPORTS AND REFERENCE SOURCES: Project digest and full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, photovoltaic, chalcopyrite, thin film semi-conductors, spray pyrolysis

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Design and development of tunnel junction photoanodes

OERD REFERENCE NO: 4.2.4	DSS FILE NO: 01SX.31155-1-2698A
STATUS: COMPLETED	
CONTRACT START DATE: 82 07 26	COMPLETION DATE: 83 11 10

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CONTRACT PRICE:
$78 335

FUNDING AGENCY:
Solar Energy Program,
National Research Council
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PROJECT PRECIS:

The main purpose of this contract was to fabricate and test a CdSe/p^+nSi tandem tunnel junction photoanode for a liquid junction solar cell. An additional objective was to establish the values of the charge carrier densities required for tunnelling to occur. A three-chamber hot wall evaporator was constructed enabling CdSe films with donor electron densities of between 10^{14} and 10^{19} cm^{-3} to be grown on either p^+nSi or high resistivity Si substrates. Those films deposited on the latter substrates were used for Hall effect and resistivity measurements.

To obtain good adhesion and the occurrence of tunnelling it was concluded that the CdSe films needed to be less than 8 μm thick and have donor electron densities approaching 10^{19} cm^{-3}. By the end of the contract a photoanode of 11% efficiency had been fabricated.

REPORTS AND REFERENCE SOURCES: This project digest and full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building M-55, Ottawa, Ontario K1A 0S2.

KEY WORDS: Solar, photovoltaic, thin film, photoanode

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Amorphous silicon solar cells - Phase II

OERD REFERENCE NO: 4.2.4 DSS FILE NO: 01SX.31155-2-2717

STATUS: COMPLETED

CONTRACT START DATE: 82 11 30 COMPLETION DATE: 84 03 15

CONTRACTOR:
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CONTRACT PRICE:
$103 316

FUNDING AGENCY:
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National Research Council
Bldg. R-92, Montreal Road
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PROJECT PRECIS:

The principal objective of this work was to perform a preliminary evaluation of an alternative to the hydrogenation method of reducing the density of localized states in a-Si. Since it is known that strong electric fields influence the nucleation and growth of vapour deposited thin films the project studied the growth of a-Si films in such fields and measured the electrical and optical properties of the obtained films.

The room temperature electrical conductivity in samples grown under a positive electrical bias was reduced by several orders of magnitude with respect to unbiased samples. Furthermore, the conductivity versus temperature curves for the biased samples resembled those observed in a-Si:H films. Co-evaporation of Si and Al increased the conductivity by a factor of 100. The optical absorption is similar to that of a direct gap semiconductor in the same way as a-Si:H but the energy gap is smaller at about 1.5 eV.

A secondary objective was to study the effect of small amounts (1-3%) of atomic hydrogen incorporation, the gas being provided at the growing film surface from a saddle field iron source. It was found that the addition of this atomic hydrogen further optimized the electrical and optical properties of the fabricated films beyond the changes produced by positive bias alone.

REPORTS AND REFERENCE SOURCES: The full report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, photovoltaic, silicon, a-Si, solar cells, hydrogen, a-Si:H

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Amorphous silicon thin film photovoltaic devices

OERD REFERENCE NO: 4.2.4 **DSS FILE NO:** 01SX.31155-2-2718

STATUS: COMPLETED

CONTRACT START DATE: 82 10 29 **COMPLETION DATE:** 84 02 29

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CONTRACT PRICE:
$90 491

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PROJECT PRECIS:

The objective of this work was to produce a-Si:C with as little contamination as possible and in particular to avoid the addition of hydrogen for the purpose of eliminating gap-states. A dependence on hydrogen to tie up the dangling bonds in a-Si will necessarily produce unstable material and devices. The approach of this work was to produce a-Si:C films with a structure close to that of an ideal random network. This material is expected to be stable under a wide variety of conditions including those appropriate to normal operating conditions for a solar cell.

The chosen preparation method was vacuum evaporation of pure silicon from a stable crucible material (pure carbon was found to be appropriate) onto a substrate held at 100°C, in a vacuum system with a base pressure of 10^{-9} Torr. During film deposition the surface of the film was "etched" in such a way that the film grew with a smooth surface. This "etching" was achieved by flooding the film surface with energetic electrons from an electron beam gun.

These methods produced a-Si:C films with room temperature resistivities near 10^{8} Ω, conductivity activation energies of 0.79 eV and optical gaps ~1.8 eV, all comparable with these parameters for a-Si:H. The photo current is ~100 times the dark current at low temperatures and is observable well above room temperature.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Photovoltaic, thin film, Si, amorphous, a-Si:C

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Technological development leading to the fabrication of a prototype amorphous silicon p-i-n photovoltaic device

OERD REFERENCE NO: 4.2.4 DSS FILE NO: 01SX.31155-2-2719

STATUS: COMPLETED

CONTRACT START DATE: 82 10 18 COMPLETION DATE: 84 03 15

CONTRACTOR:
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CONTRACT PRICE:
$158 381

FUNDING AGENCY:
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National Research Council
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PROJECT PRECIS:

A new technique for the doping of amorphous hydrogenated silicon by the controlled evaporation of metallic antimony, indium, or thallium into an RF plasma discharge of silane and argon was successfully demonstrated. For conductivity measurements in the coplanar geometry, activation energies of 0.1 eV for Sb and 0.4 eV for In and Tl were observed. All doped samples have an optical energy gap of 1.7 eV, characteristic of the intrinsic material but are not photoconductive. Typically these films contain approximately 8-12% hydrogen, 1% argon, up to 1% dopant, and less than 0.5% of carbon, nitrogen, and oxygen contaminants.

Schottky, p-i, n-i, and p-i-n solar cell structures were fabricated using a variety of electrode materials. Under AM1 illumination the following efficiencies were observed:

STRUCTURE	DEVICE TYPE	EFFICIENCY
Au/a-Si:H/Sb/Cr/7059 glass	Schottky	5.3%
Mg/a-Si:H,Sb/a-Si:H/Sb/Cr/7059	n-i	2.0%
Mg/a-Si:H,Tl/a-Si:H/Sb/Cr/7059	p-i	1.0%
Au/a-Si:H,Sb/a-Si:H/a-Si:H,Tl/Sb/Cr/7059	p-i-n	1.0%

Since the production facilities available required breaking vacuum between the growth of the p and i layers of the p-i-n device significant carbon and oxygen contamination was detected in the intrinsic layer causing its low efficiency. However in this device a built-in voltage of 1.1 V was observed.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, photovoltaic, amorphous silicon

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Thin Film GaAs on Ge solar cells

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31155-2-2724
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	82 03 21	COMPLETION DATE:	84 07 15
NEXT MILESTONE & DATE:	83 07 15		

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CONTRACT PRICE:
$56 144

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A number of thin film heteroepitaxial solar cell structures will be fabricated and characterized. These structures are of interest as potentially low cost, high power conversion efficient, large area cells to replace more expensive silicon-based cells. The basis of the cells will be gallium arsenide pn junctions grown on low cost germanium substrates. Other features it is proposed to build into the cells are a graded band structure film and a window for frequency down conversion of the solar radiation. Both these features should increse the inherent high power conversion efficiency of the active GaAs.

Three variants of the chemical vapour deposition (CVD) method of growing GaAs will be employed and assessed. Basic spectrophotometry and Hall effect measurements as a function of temperature will be used to evaluate the grown films and the I-V curves of the junctions with and without illumination will be studied.

KEY WORDS: Photovoltaic, thin film, GaAs, Si, solar cell

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Design and development of tunnel junction solar cells (Phase II)	
OERD REFERENCE NO: 4.2.4	DSS FILE NO: 01SX.31926-3-3017
STATUS: IN PROGRESS AS OF: 84 04 30	
CONTRACT START DATE: 83 08 04	COMPLETION DATE: 84 08 03
NEXT MILESTONE & DATE: 84 08 03	
CONTRACTOR: Infrared Photo Ltd. 74 Burland Street Ottawa, Ontario K2B 6K1	PRINCIPAL INVESTIGATOR: W.E. Pinson (613) 828-0683
NRC PROJECT MANAGER: M. Buchanan Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $98 715	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The ultimate main objective of this contract is to fabricate and evaluate a tandem cell structure of the form Au/ZnSe/CdSe/p^+nSi. However, the initial work will concentrate on optimization of the growth of CdSe films which will involve modification of a three-chamber hot wall evaporator, doping of the films, and annealing studies. The structure built to the stage of CdSe/p^+nSi will be evaluated using an electrochemical test cell which will be constructed for this purpose.

A secondary objective is the preliminary investigation of the alternative tandem cell structure of $n^+i\alpha$-Si/p^+nSi

KEY WORDS: Solar, photovoltaic, tunnel junction, solar cell

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Development of materials and production technology for thin-film $CuInSe_2$ solar cells		
OERD REFERENCE NO:	4.2.4	**DSS FILE NO:**	01SX.31926-3-3018
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 12 29	**COMPLETION DATE:**	85 02 05
NEXT MILESTONE & DATE:	85 02 05		

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CONTRACT PRICE:
$113 445

FUNDING AGENCY:
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National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is to develop thin film solar cell structures based on $CuInSe_2$ as the absorber layer.

Films of $CuInSe_2$ and CuIn will be prepared by flash evaporation techniques from both powder and wire samples. The starting powders will be formed from homogeneous melts of copper, indium, and selenium whilst copper plated indium wire will be fabricated for co-evaporation with selenium in the alternative approach. Optimisation of the growth procedures will be carried out to attain the desired structural, optical, and electrical properties.

The target is the production of large grain polycrystalline films of $CuInSe_2$ of uniform stoichiometry with low resistivity (<50 Ω cm). It is anticipated that the grown films will be p-type and the aim is to achieve a carrier concentration of $>10^{16}/cm^3$.

KEY WORDS: Solar, photovoltaic, $CuInSe_2$, solar cells, thin-film

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Electrodeposited cadmium telluride solar cells

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3019
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 08 17	COMPLETION DATE:	84 08 08
NEXT MILESTONE & DATE:	84 08 08		

CONTRACTOR:
A.D. Plating & Electroforming
110 Aikman Avenue
Hamilton, Ontario
L8M 1P9

PRINCIPAL INVESTIGATOR:
N. Dalacu
(416) 523-4636

NRC PROJECT MANAGER:
M. Buchanan
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

NRC PROJECT SCIENTIST:
I. Beswarva
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$46 665

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is to develop methods to form thin film solar cells based on a CdTe absorber layer.

The principal method of growing the CdTe films will be by electrodeposition. Optimisation of the growth parameters will be carried out to attain the desired structural, optical, and electrical properties. Both n-type and p-type layers are to be grown and initially Schottky devices with gold metallic layers will be fabricated to assess the photovoltaic properties.

A significant fraction of the characterisation will be carried out in the Department of Engineering Physics at McMaster University under a subcontract including use of Auger analysis, scanning electron microscopy, and x-ray diffraction.

KEY WORDS: Solar, photovoltaic, CdTe, thin film, solar cells

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Fabrication of a prototype low-cost CdS/CdTe heterojunction solar cell using a novel spraying technique		
OERD REFERENCE NO:	4.2.4	**DSS FILE NO:**	01SX.31926-3-3020
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 10 25	**COMPLETION DATE:**	84 10 01
NEXT MILESTONE & DATE:	84 10 01		

CONTRACTOR:
Silonex Inc.
2150 Ward Street
Montreal, Quebec
H4M 1T7

PRINCIPAL INVESTIGATOR:
P. Petrov
(514) 744-5507

NRC PROJECT MANAGER:
M. Buchanan
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

NRC PROJECT SCIENTIST:
I. Boswarva
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$167 482

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The principal objective of this contract is to establish a spraying technique to deposit thin films of CdS and CdTe which have good adhesion to glass substrates. Subsequent annealing processes will be developed to optimize the structural, optical, and electrical properties of the films to make them suitable for use in solar cell fabrication.

Following the completion of these tasks a method of obtaining low-resistance ohmic contacts will be established and a prototype CdS/CdTe photovoltaic device within a hermetically sealed housing will be fabricated.

KEY WORDS: Solar, photovoltaic, thin film, CdS, CdTe

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of germanium on silicon substrates for thin film gallium arsenide solar cells	
OERD REFERENCE NO: 4.2.4	DSS FILE NO: 01SX.31926-3-3021
STATUS: COMPLETED	
CONTRACT START DATE: 83 10 05	COMPLETION DATE: 84 05 09
CONTRACTOR: TPK Solar Systems Inc. 36 Bentley Avenue Nepean, Ontario K2E 6T7	PRINCIPAL INVESTIGATOR: C.E. Norman (613) 225-4403
NRC PROJECT MANAGER: M. Buchanan Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $60 156	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The purpose of this contract was to deposit epitaxial layers of germanium on silicon wafers. The resultant structures can subsequently be used as substrates for the fabrication of thin film gallium arsenide solar cells. The germanium layers were produced by electron beam evaporation on to a heated silicon substrate and two different approaches to substrate preparation were investigated. In both approaches the cleaned wafers were oxidised at 900°C in dry oxygen to form an oxide layer which was subsequently removed by a HF etch immediately prior to loading into the evaporation equipment. In one case the wafers were just loaded as fast as possible to minimise another oxidation or contamination whilst in the other the wafers were first dipped into saturated methyl iodine solution. The purpose of this extra step was to passivate the surface with iodine which could then be desorbed when the low pressure had been attained in the apparatus.

Experiments were performed to determine the effect of varying other deposition conditions such as substrate temperature, deposition rate, and film thickness. The resulting films were characterized structurally using scanning electron microscopy, glancing angle X-ray diffraction and reflection high-energy electron diffraction, and electrically using four point probe measurements.

It was concluded that successful Ge-Si heteroepitaxy requires careful substrate preparation to obtain and maintain a clean Si surface into the vacuum chamber and the correct combination of background pressure, substrate temperature, and deposition rate. Whilst good results can be achieved for a range of values of each parameter the optimum value for any one parameter depends to some extent on the others.

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar, photovoltaic, germanium, silicon, GaAs, solar cells.

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of second generation photovoltaic modules

OERD REFERENCE NO: 4.2.4 **DSS FILE NO:** 02SX.31155-1-2647

STATUS: COMPLETED

CONTRACT START DATE: 81 09 24 **COMPLETION DATE:** 84 03 31

CONTRACTOR:
Silonex Inc.,
2150 Ward Street,
Montreal, Que.
H4M 1T7

PRINCIPAL INVESTIGATOR:
D.A. Anderson
(514) 744-5507

NRC PROJECT MANAGER:
M. Buchanan
Solar Energy Program,
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6
(613) 993-2730

NRC PROJECT SCIENTIST:
D. Williams
Division of Chemistry,
100 Sussex Drive,
Ottawa, Ontario, K1A 0R6
(613) 992-5614

CONTRACT PRICE:
$263 300

FUNDING AGENCY:
Solar Energy Program,
National Research Council
Bldg. R-92, Montreal Road,
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

By the completion of the contract excellent quality lamination of the set of solar cells for a module into a Tedlar-EVA craneglas combination could be carried out on a routine basis. A new design of extruded aluminum frame with superior corrosion resistance and shock protection has been incorporated into the module production. A vacuum operated cell positioning jig has been designed and built.

Plasma-etching techniques for pre-diffusion cleaning, photoresist stripping, and removal of the diffused layer on the back of the cell were all successfully developed. These techniques are vastly superior in the use of manpower compared with the standard wet chemistry procedures.

A preliminary investigation of the use of screen-printing of the electrode grids was also carried out.

REPORTS AND REFERENCE SOURCES: The full report is available on lean from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario K1A 0S2

KEY WORDS: Photovoltaic, solar cells, manufacture, plasma, lamination

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: The development of oxide-semiconductor on silicon, semiconductor-insulator-semiconductor solar cells

OERD REFERENCE NO: 4.2.4 DSS FILE NO: 02SX.31155-1-2657

STATUS: COMPLETED

CONTRACT START DATE: 81 12 15 COMPLETION DATE: 84 01 09

CONTRACTOR:
Solar Cells Limited,
P.O. Box 1025,
Burlington, Ontario
L7P 3S9

PRINCIPAL INVESTIGATOR:
J. Shewchun
(416) 335-4713

NRC PROJECT MANAGER:
M. Buchanan
Solar Energy Program,
Bldg. 92, Montreal Rd.,
Ottawa, Ontario, K1A OR6
(613) 993-2730

NRC PROJECT SCIENTIST:
M. Buchanan
Solar Energy Program
Bldg. 92, Montreal Road,
Ottawa, Ontario, K1A OR6
(613) 993-2730

CONTRACT PRICE:
$164 699

FUNDING AGENCY:
Solar Energy Program,
National Research Council,
Bldg. 92, Montreal Rd.,
Ottawa, Ontario, K1A OR6

PROJECT PRECIS:

Solar cells of this type consist of a thin film of a transparent conducting oxide and a light-absorbing semiconductor substrate, normally polycrystalline silicon, separated by an insulating layer of about 15-20 angstroms thickness. Potentially these cells can be produced significantly cheaper than standard silicon cells but it is essential to obtain efficiencies approaching 15% and a lifetime stability of the order of twenty years.

The basic objective of this contract was to produce such cells on large-area (10x10 cm) polycrystalline silicon substrates using the spray pyrolysis technique to deposit the conducting oxide layers. Cells were produced with an average efficiency of 14% with selected cells of somewhat higher efficiency. The spray pyrolysis process was optimised with respect to the chemistry of the spray solution, the aerosol/atomization mechanism, the transport and ambient gas system, substrate temperature, and the effect of dopants. To overcome the deleterious effects of grain boundaries in the substrates both a chemical etch process and a hydrogen annealing procedure were developed and used prior to the oxide deposition. The grooved surface produced by the etchant also had a beneficial anti-reflecting effect.

Some preliminary work was also carried out which indicated further potential improvements by the use of ultar-thin substrates with electronic carrier and light reflecting back surfaces and the substitution of zinc oxide for the routinely used indium tin oxide.

REPORTS AND REFERENCE SOURCES: The project digest and the full report are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Montreal Road, Building R-105, Ottawa, Ontario, K1A OS2

KEY WORDS: SIS, ITO, polycrystalline silicon, chemical spray pyrolysis, solar cells, photovoltaic, solar

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Development of low cost, large area silicon substrates for solar cells	
OERD REFERENCE NO: 4.2.4	**DSS FILE NO:** 02SX.31155-2-2720
STATUS: COMPLETED	
CONTRACT START DATE: 82 09 22	**COMPLETION DATE:** 84 04 30
CONTRACTOR: T.P.K. Solar Systems Inc. 149 Bentley Ave. Nepean, Ontario K2E 6I7	**PRINCIPAL INVESTIGATOR:** C.E. Norman (613) 225-4403
NRC PROJECT MANAGER: M. Buchanan Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	**NRC PROJECT SCIENTIST:** I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $155 259	**FUNDING AGENCY:** Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

The purpose of this contract was to investigate new methods for fabricating solar cell substrates from metallurgical grade silicon (MG-Si) with the ultimate goal of low cost, large volume production. Three aspects were examined, namely:

1. improvement of acid-leaching processes
2. development of pressing and sintering techniques to fabricate hard but still porous wafers
3. development of electron-beam annealing to produce smooth and sealed wafers

A fast three-step leaching process suitable for industrial scale-up was established. Isostatic pressing up to 40 000 p.s.i. was used to compact the powder into briquettes which could be sliced into wafers prior to sintering. Subsequent sintering produced p-type wafers with resistivities in the range 0.02 to 0.07 ohm-cm. The electron beam heating induced a melt zone which was scanned across the substrate leaving a smooth, sealed flat surface in its wake. It was found that as an alternative to the sintering step a preliminary low power electron beam scan could be used. Furthermore the slicing procedure can also be dispensed with by spreading the leached MG-Si powder on a reusable graphite substrate, compacting, and then using the low power e-beam scan.

REPORTS AND REFERENCE SOURCES: The project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2. The full report will be released in February 1985.

KEY WORDS: Solar, photovoltaic, polycrystalline, solar cells

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Testing and evaluation of high efficiency modular power conditioning systems for photovoltaics	
OERD REFERENCE NO: 4.2.4	DSS FILE NO: 01SX.31155-1-2658B
STATUS: IN PROGRESS AS OF: 84 03 30	
CONTRACT START DATE: 82 07 02	COMPLETION DATE: 84 07 15
NEXT MILESTONE & DATE: 84 07 15	
CONTRACTOR: T.P.K. Solar Systems Inc. 149 Bentley Avenue Nepean, Ontario K2E 6T7	PRINCIPAL INVESTIGATOR: R.E. Thomas (613) 225-4403
NRC PROJECT MANAGER: M. Buchanan Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730	NRC PROJECT SCIENTIST: J. G. Rumbold Solar Energy Program Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6 (613) 993-2730
CONTRACT PRICE: $118 385	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Rd. Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The viability of generalized high efficiency modular power conditioning systems for photovoltaics is to be demonstrated. Maximum power delivery to the load is an essential feature and the modules are to be digitally based and microprocessor controlled resulting in flexibility, high efficiency, lightness, and temperature insensitivity.

Three tasks are to be addressed. The first task is to design and construct a microprocessor controlled maximum power point tracker (MPPT) with DC to DC transformer up-conversion.

The second task is aimed at determining the advantages to be gained over DC to DC transformers by the switching of photovoltaic modules in series and parallel combinations to optimize the power output. A microprocessor based system will be designed and prototyped. The power level trade-off point for the two MPPT approaches will be established.

The third task is to address the design and production of a prototype programmable DC to AC inverter of high efficiency (> 90%).

KEY WORDS: Modular, photovoltaic, power conditioning, tracker, inverter microprocessor control

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Limited power low-cost photovoltaic systems for remote residences		
OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3022
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 10 25	COMPLETION DATE:	84 06 11
NEXT MILESTONE & DATE:	84 06 11		

CONTRACTOR: Adkinson & Associates 1520 Trinity Drive, Unit 12 Mississauga, Ontario L5T 1L6	PRINCIPAL INVESTIGATOR: D.J. Adkinson (416) 676-9040
NRC PROJECT MANAGER: M. Buchanan Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730	NRC PROJECT SCIENTIST: I. Boswarva Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-2730
CONTRACT PRICE: $32 030	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

This contract has four principal objectives, namely:

a) to develop a detailed design for a "limited power" photovoltaic system for remote residences in Canada
b) to determine areas of weakness in appropriate hardware design or availability for Canadian remote residence limited power photovoltaic systems
c) to develop a current and projected cost of such systems in five isolated Canadian locations
d) to determine geographic and environmental parameters for practical application of such systems.

KEY WORDS: Solar, photovoltaic, remote, systems, residential

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Photovoltaic powered desalination

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3024
STATUS: IN PROGRESS AS OF:	84 03 31		
CONTRACT START DATE:	83 11 29	COMPLETION DATE:	84 11 14
NEXT MILESTONE & DATE:	84 11 14		

CONTRACTOR:
Bowie Keefer and Associates
475 West Georgia Street, Suite 560
Vancouver, B.C.
V6B 4M9

PRINCIPAL INVESTIGATOR:
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(604) 687-2859

NRC PROJECT MANAGER:
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(613) 993-2730

NRC PROJECT SCIENTIST:
J.G. Rumbold
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$124 855

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is the design optimization and prototype development of a stand-alone solar photovoltaic powered reverse osmosis desalination system.

Both brackish and sea water desalting will be studied. The system will utilize an energy recovery pump invented and developed by Bowie Keefer to produce a high efficiency desalination system which would be compatible with photovoltaic power for use in remote areas.

KEY WORDS: Solar, photovoltaic, reverse osmosis, desalination

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Photovoltaic-powered lighting system

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3025
STATUS: IN PROGRESS AS OF:	84 03 31		
CONTRACT START DATE:	83 12 29	COMPLETION DATE:	85 02 15
NEXT MILESTONE & DATE:	85 02 15		

CONTRACTOR:
Lenbrook Industries Ltd.
1145 Bellamy Road
Scarborough, Ontario
M1H 1H5

PRINCIPAL INVESTIGATOR:
D. Adkinson
(416) 438-4610

NRC PROJECT MANAGER:
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Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

NRC PROJECT SCIENTIST:
J.G. Rumbold
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$90 686

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is to design, build, and field test a prototype photovoltaic powered lighting system.

The contract will include a definition of the operational requirements of lighting devices, a review of current state-of-the-art light source technology, an examination of power-saving control strategies, the building of a prototype, and the conducting of a field trial.

KEY WORDS: Solar, photovoltaic, lighting

NRC/SEP PROJECT SUMMARY SHEET — INTERIM

PROJECT TITLE:	Development of a photovoltaic-powered shallow well pumping system		
OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3029
STATUS: IN PROGRESS AS OF:	84 03 31		
CONTRACT START DATE:	83 11 21	COMPLETION DATE:	84 06 05
NEXT MILESTONE & DATE:	84 06 05		

CONTRACTOR:
TPK Solar Systems Inc.
149 Bentley Avenue
Nepean, Ontario
K2E 6T7

PRINCIPAL INVESTIGATOR:
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(613) 225-4403

NRC PROJECT MANAGER:
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Solar Energy Program
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(613) 993-2730

NRC PROJECT SCIENTIST:
J.G. Rumbold
Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-2730

CONTRACT PRICE:
$93 864

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is the design and development of a PV powered shallow well pumping system.

Currently available pumps and motors will be evaluated to determine their suitability for the present application. A shallow well prototype pump system will be built and tested in the laboratory.

KEY WORDS: Solar, photovoltaic, pump, water pumping

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Photovoltaic - powered systems for medium head pumping			
OERD REFERENCE NO:	4.2.4	**DSS FILE NO:**	01SX.31926-3-3030
STATUS: IN PROGRESS AS OF:	84 04 31		
CONTRACT START DATE:	83 10 27	**COMPLETION DATE:**	84 10 12
NEXT MILESTONE & DATE:	84 10 12		

CONTRACTOR:
Peter Ward and Associates
3408 West 40th Avenue
Vancouver, B.C.
V6N 3B6

PRINCIPAL INVESTIGATOR:
P. Ward
(604) 688-8271

NRC PROJECT MANAGER:
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(613) 993-2730

NRC PROJECT SCIENTIST:
J.G. Rumbold
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$86 313

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The objective of this contract is to develop and test a PV array, motor, and pump combination for water pumping.

The system is to be designed for medium head (25 to 45 m) pumping and will utilize a progressing cavity pump. A hydraulic test loop will be constructed to test the pumping system.

KEY WORDS: Solar, photovoltaic, pump, water pumping

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	A novel microcomputer data acquisition system to investigate site suitability for photovoltaic use in Canadian mountain winter conditions		
OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3023
STATUS: IN PROGRESS AS OF:	84 04 12		
CONTRACT START DATE:	83 12 12	COMPLETION DATE:	84 06 29
NEXT MILESTONE & DATE:	84 06 29		

CONTRACTOR:
EKEG Electronics Co. Ltd.
P.O. Box 46199, Station "G"
Vancouver, B.C.
V6R 4G5

PRINCIPAL INVESTIGATOR:
P. Graystone
(604) 685-7817

NRC PROJECT MANAGER:
M. Buchanan
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

NRC PROJECT SCIENTIST:
J.G. Rumbold
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$69 960

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The aim of this project is the design, development, and field trial of a site evaluation system to determine site suitability for use of PV power.

A battery powered microcomputer data acquisition system with non-volatile memory is to be developed to permit unattended operation for a complete winter season. The evaluation system will record temperature, wind speed and direction, insolation and output from a standard PV module from which the performance of a PV system can be determined.

KEY WORDS: Solar, photovoltaic, site evaluation, data acquisition

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Small photovoltaic power systems

OERD REFERENCE NO: 4.2.4 DSS FILE NO: 01SX.31926-3-3031

STATUS: IN PROGRESS AS OF: 84 03 30

CONTRACT START DATE: 83 12 08 COMPLETION DATE: 84 11 30

NEXT MILESTONE & DATE: 84 11 30

CONTRACTOR:
University of Waterloo
Waterloo, Ontario
N2L 3G1

PRINCIPAL INVESTIGATOR:
M. Chandrashekar
(519) 885-1211 Ext. 3113

NRC PROJECT MANAGER:
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Solar Energy Program
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NRC PROJECT SCIENTIST:
I. Boswawa
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6
(613) 993-2730

CONTRACT PRICE:
$49 659

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

Under this contract an extensive survey of the technical literature will be carried out to gather and assess up-to-date information on photovoltaic water pumping systems. Additionally, as a separate task, the availability and suitability of existing computer simulation models of such systems will be investigated.

Following this survey work modifications of existing computer models and development of new models will be undertaken as necessary. A set of photovoltaic pumping systems will be selected for modelling simulation and optimization. The results of these computer studies will be presented as a report along with conclusions and recommendations.

KEY WORDS: Solar, photovoltaic, water pumping, simulation

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Monitoring of a 4 kW photovoltaic power system

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	27ST.31926-4-3000
STATUS: IN PROGRESS AS OF:	84 03 30		
CONTRACT START DATE:	84 03 09	COMPLETION DATE:	84 10 01
NEXT MILESTONE & DATE:	84 10 01		

CONTRACTOR:
Technical University of Nova Scotia
Department of Electrical Engineering
P.O. Box 1000
Halifax, Nova Scotia, B3J 2X4

PRINCIPAL INVESTIGATOR:
W.Z. Fam
(902) 429-8300

NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
I. Boswarva
Solar Energy Program
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(613) 993-2730

CONTRACT PRICE:
$3300

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The purpose of this contract is to interface government-supplied data acquisition equipment with the 4 kW photovoltaic power system owned by the university. Subsequently the system is to be monitored and the recorded data sent to NRC at regular intervals.

The following quantities are to be monitored:

Array - Current, voltage, power, current from one or several individual strings
Power Conditioner - Maximum power point tracker output power
Inverter outputs (current, voltage, power)
Load - Current, voltage, power
Storage Battery - Terminal voltage, net charging/discharging current

Additionally the total solar radiation on the array plane, ambient temperature, and wind speed and direction will be recorded. Each item will be sampled at a frequency of one minute and hourly average values recorded.

KEY WORDS: Solar, photovoltaic, monitoring

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Development of photovoltaic module testing capability

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-0085
STATUS: IN PROGRESS AS OF:	84 04 12		
CONTRACT START DATE:	83 08 26	COMPLETION DATE:	84 08 31
NEXT MILESTONE & DATE:	84 08 31		

CONTRACTOR:
Ontario Research Foundation
Sheridan Park Research Community
Mississauga, Ontario
L5K 1B3

PRINCIPAL INVESTIGATOR:
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(416) 822-4111

NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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Solar Energy Program
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(613) 993-2730

CONTRACT PRICE:
$179 011

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The purpose of this contract is to extend the photovoltaic module testing capability of ORF and to permit routine testing of PV modules to be carried out at the NSTF (National Solar Test Facility).

In particular ORF will extend their capability to permit the testing of high power modules and arrays, modules constructed of material other than crystalline silicon, and to permit module hot spot testing and nominal operating cell temperature (NOCT) determination.

ORF will be continuing their cooperative effort with the Jet Propulsion Laboratory (JPL) in the areas of PV module electrical measurement and NOCT determination.

KEY WORDS: Solar, photovoltaic, testing

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Technical survey of small photovoltaic-powered pumping systems

OERD REFERENCE NO:	4.2.4	DSS FILE NO:	01SX.31926-3-3027
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 11 29	COMPLETION DATE:	84 11 30
NEXT MILESTONE & DATE:	84 11 30		

CONTRACTOR:
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Sheridan Park Research Community
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT SCIENTIST:
I. Boswarva
Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-2730

CONTRACT PRICE:
$144 728

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

The first objective of this contract is to produce and deliver a review of current photovoltaic pumping technology and a survey of commercial systems available worldwide.

The second objective is to design, build, and test a facility capable of producing performance measurements of such photovoltaic water pumping systems. Under the contract the performance of several systems will subsequently be measured.

The third objective is to construct and validate a computer model of such systems to enable optimisation of designs for specific locations to be achieved.

KEY WORDS: Solar, photovoltaic, pump, test facility, performance

CORE APPLICATIONS

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NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Investigation of flow distribution in solar collector arrays

OERD REFERENCE NO:	4.2.5	DSS FILE NO:	04SX.31926-3-3011
STATUS: IN PROGRESS AS OF:	84 04 05		
CONTRACT START DATE:	83 11 30	COMPLETION DATE:	84 08 31
NEXT MILESTONE & DATE:	84 08 31		

CONTRACTOR:
Solarsystems Industries Ltd.
2-1171 Horseshoe Way
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V7A 4S5

PRINCIPAL INVESTIGATOR:
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(604) 271-2621

NRC PROJECT MANAGER:
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Solar Energy Program
Bldg. R-92, Montreal Road
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(613) 993-9224

NRC PROJECT SCIENTIST:
W.E. Carscallen
Solar Energy Program
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6
(613) 993-9224

CONTRACT PRICE:
$45 672

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The distribution of flow in collector arrays using internal manifolds will be investigated and a mathematical model developed for a number of header and riser sizes.

Full scale models of collector arrays with up to 32 collectors will be constructed and the flow distribution measured using 30 calorimetric flow meters. Three different flow rates will be used in each array using water as the fluid. A 50/50 glycol/water mixture will be used to duplicate three of the test runs.

KEY WORDS: Solar, collector, flow distribution, array

NRC/SEF PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: A study of diffuse sky radiation simulation capability for the National Solar Test Facility	
OERD REFERENCE NO: 4.2.5	DSS FILE NO: 04SR.31926-4-5000
STATUS: IN PROGRESS AS OF: 84 04 29	
CONTRACT START DATE: 84 03 14	COMPLETION DATE: 84 09 17
NEXT MILESTONE & DATE: 84 09 17	
CONTRACTOR: Hooper and Angus Assoc. Ltd. 950 Yonge Street, Suite 502 Toronto, Ontario M4W 2J7	PRINCIPAL INVESTIGATOR: F.C. Hooper (416) 961-4151
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: G. Yen Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $19 950	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT OBJECTIVE AND DESCRIPTION:

A study of the technical feasibility of modifying the solar simulator at the National Solar Test Facility at Ontario Research Foundation is to be carried out. Such a modification would provide for the simulation of the diffuse component of solar radiation.

Preliminary specifications for the angular distribution, intensity, and area of target coverage are to be prepared and an assessment of alternative approaches including reflecting surfaces and auxiliary sources made. The anticipated performance will be assessed and the cost of installation estimated.

KEY WORDS: Solar, simulator, NSTF, diffuse radiation

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Operation of the WATSUN User Service Facility

OERD REFERENCE NO: 4.2.5	DSS FILE NO: 03SU.31155-2-2777
STATUS: COMPLETED	03SU.31155-2-2777A
CONTRACT START DATE: 82 11 05	COMPLETION DATE: 83 12 31

CONTRACTOR:
Waterloo Research Institute
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Waterloo, Ontario
N2L 3A1

PRINCIPAL INVESTIGATOR:
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(519) 885-1211

NRC PROJECT MANAGER:
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NRC PROJECT SCIENTIST:
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Ottawa, Ontario, K1A 0R6
(613) 993-9224

CONTRACT PRICE:
$134 646 (2-2777)
$ 29 832 (2-2777A)

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

These reports summarize the activities of the WATSUN User Service for the periods October 1, 1982 to September 30, 1983 (Phase 2) and October 1, 1983 to December 21, 1983 (Phase 2 extension).

The WATSUN User Service provides technical support, software development, education, and other related functions for the series of interactive computer programs called WATSUN. These programs are used by government agencies, engineering consultants, and solar system manufacturers in the design and evaluation of active solar systems.

Technical support for customers is beginning to consume a significant amount of the User Service time and the number of link-based customers has doubled. The programs have been improved through the adoption of coding standards, ongoing debugging, redesigning of output and so on. Pipe heat loss and more flexible incidence angle models have been incorporated into DHWA. Work is in progress on the next WATSUN version, the development of typical meteorological years and a microcomputer version of WATSUN. The educational efforts included two workshops and a demonstration. Further documentation is available from the WATSUN User Service.

REPORTS AND REFERENCE SOURCES: These reports are available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: WATSUN, simulation, solar, user service

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Establishment of a mechanical testing facility for the development of solar components	
OERD REFERENCE NO: 4.2.5	DSS FILE NO: 04SX.31155-0-2683A
STATUS: COMPLETED	
CONTRACT START DATE: 82 06 08	COMPLETION DATE: 83 10 18
CONTRACTOR: Centre de recherche industrielle du Québec 333 rue Franquet Sainte-Foy, Québec G1V 4C7	PRINCIPAL INVESTIGATOR: Y. Coté (418) 659-1550
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $70 108	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

A mechanical testing facility for solar materials and components has been established at the Centre de recherche industrielle du Québec (CRIQ). This facility is intended to serve the Province of Québec and surrounding areas, and complements the thermal performance testing facility established at the Institut national de la recherche scientifique (INRS) at Varennes, Québec.

The additional equipment required to extend the capability of CRIQ's existing facilities, in order to serve solar applications, was identified in Phase I of Contract No. 04SX.31155-0-2683.

This project essentially covered the Phase II portion of the preceeding contract, and provided for the procurement, installation, try-out testing, and calibration of the identified instrumentation and equipment.

REPORTS AND REFERENCE SOURCES: Contract report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Mechanical testing, solar, materials, components

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE: Improvement of the solar simulator lamp spectrum

OERD REFERENCE NO: 4.2.3	DSS FILE NO: 04SX.31155-2-2793
STATUS: IN PROGRESS AS OF: 82 12 21	
CONTRACT START DATE: 82 09 30	COMPLETION DATE: 84 07 04
NEXT MILESTONE & DATE: 84 07 04	

CONTRACTOR:
Vortek Industries Ltd.
1820 Pandora Street
Vancouver, B.C. V5L 1M5

PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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Solar Energy Program
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6
(613) 993-2730

NRC PROJECT SCIENTIST:
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Division of Physics
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Ottawa, Ontario, K1A OR6
(613) 993-2094

CONTRACT PRICE:
$16 430

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Rd.
Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

Liquid dip multilayer coatings for the Vortek solar simulator produced the air mass 2 (AM2) spectrum desired for solar collector testing but were uneven and unstable in use. (See NRC contract no. 081-939/1-2625.)

The current contract will investigate the use of these coatings on Mylar placed inside the plasma tube adjacent to the water wall.

Uncoated Mylar will be tested to determine if it has any effect on water flow. This will be followed by the testing of vacuum evaporated coatings for mechanical behaviour. If the experiments with Mylar are unsuccessful, the coatings will be tested on the outside of the tube. Then up to four iterations of film design will be made to achieve the AM2 spectrum.

KEY WORDS: Solar, simulator, Vortek, spectrum

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Support of solar standards development during fiscal year 1983/84	
OERD REFERENCE NO: 4.2.5	DSS FILE NO: 04SX.31926-3-0004
STATUS: COMPLETED	
CONTRACT START DATE: 83 08 24	COMPLETION DATE: 84 05 31
CONTRACTOR: Canadian Standards Assoc. 178 Rexdale Blvd. Rexdale, Ontario M9W 1R3	PRINCIPAL INVESTIGATOR: Linda LaVecchia (416) 744-4078
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224
CONTRACT PRICE: $92 000	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

Under this contract, Canadian Standards Association provided support to the process of developing standards for solar collectors, solar domestic water heaters, photovoltaic modules, photovoltaic power conditioning, and photovoltaic storage.

During the fiscal period 1 April 1983 to 31 March 1984, under direction from the Canadian Solar Standards Steering Committee, CSA provided secretarial support to Technical Committees writing draft, preliminary, and final standards, prepared background information for the Committee, arranged meetings of the Committees, attended national and international meetings on solar standards, and developed and published the following spectrum of solar energy standards:

CSA Standard F378	-	Solar Collectors
CSA Standard F379.1	-	Solar DHW Systems
Preliminary CSA Standard F379.2	-	Seasonal Solar DHW Systems
Preliminary CSA Standard F380	-	Photovoltaic Modules
Draft CSA Standard F381	-	PV Power Conditioning
Draft CSA Standard F383	-	Installation Code for Solar DHW Systems

REPORTS AND REFERENCE SOURCES: This report is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2.

KEY WORDS: Solar standards, collectors, DHW systems, PV systems

NRC/SEP PROJECT SUMMARY SHEET INTERIM

PROJECT TITLE:	Upgrading and completion of the computer facility of the solar development testing center		
OERD REFERENCE NO:	4.2.5	DSS FILE NO:	04SX.31926-3-0090
STATUS: IN PROGRESS AS OF:	84 04 30		
CONTRACT START DATE:	83 09 06	COMPLETION DATE:	84 05 30
NEXT MILESTONE & DATE:	84 05 30		

CONTRACTOR: B.C. Research 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	PRINCIPAL INVESTIGATOR: M. Movassaghi Manager, Applied Energy Systems (604) 224-4331
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224	NRC PROJECT SCIENTIST: P. Sparrow Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6 (613) 993-9224
CONTRACT PRICE: $50 649	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A OR6

PROJECT OBJECTIVE AND DESCRIPTION:

The existing computer capability at B.C. Research, is to be upgraded and extended to increase the scope of the services offered by the Solar Development Testing Center in conducting tests and research for manufacturers of solar components and systems, and in providing technical advice on solar components and systems.

One personal computer system (with 1 Megabyte address space) is to be purchased and integrated with existing computer facilities. Both the WATSUN III and F-chart 4.1 simulation programs are to be procured and simulations carried out on one drainback system currently installed and being monitored. The simulations are to be compared with and reconciled to the actual performance data.

KEY WORDS: Solar, testing, simulation, WATSUN, F-chart

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Analysis of test frame calibration re-checks at the National Solar Test Facility	
OERD REFERENCE NO: 4.2.5	DSS FILE NO: 04SX.31926-3-5003
STATUS: COMPLETED	
CONTRACT START DATE: 83 08 12	COMPLETION DATE: 84 03 01
CONTRACTOR: W.R. Davis Engineering 1481 Cyrville Rd. Ottawa, Ontario K1B 3L7	PRINCIPAL INVESTIGATOR: W.R. Davis (613) 746-3760
NRC PROJECT MANAGER: K.G. Lund Solar Energy Program Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-9224	NRC PROJECT SCIENTIST: S.G. Harrison Div. of Building Research Bldg. M-24, Montreal Road Ottawa, Ontario, K1A 0R6 (613) 993-1421
CONTRACT PRICE: $9525	FUNDING AGENCY: Solar Energy Program National Research Council Bldg. R-92, Montreal Road Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

In November 1982, and again in February 1983, staff from the DBR/NRC Solar Calorimetry Laboratory visited the Toronto-based National Solar Test Facility to conduct a series of evaluations involving the ORDCO test frames. The primary objective of these evaluations was to confirm the continuing compliance of the calorimeter test loops with the accuracy requirements set forth in, and derived from, ASHRAE Standard 93-77 and CSA Standard F378-M1982.

To meet this objective, a three-level facility calibration was carried out, involving primary sensor checks, calorimetric test loop effectiveness measurements, and thermal performance testing of reference collectors.

Consequently, this contract was let with Davis Eng. to document the test performance and to provide a first compilation and analysis of data.

The contract report is now under evaluation by the Solar Calorimetry Unit and this group will publish a summary of final results concerning the calibration of test equipment by the end of 1984.

REPORTS AND REFERENCE SOURCES: A summary of this work will be published by the Division of Building Research, National Research Council, Montreal Road, Building M-24, Ottawa, Ontario, K1A 0S2

KEY WORDS: Solar, NSTF, calibration, calorimetry

NRC/SEP PROJECT SUMMARY SHEET FINAL

PROJECT TITLE: Preparation of design drawings, specifications and cost estimates for the proposed extension of the National Solar Test Facility

OERD REFERENCE NO: 4.2.5 DSS FILE NO: 04SX.31926-3-5021

STATUS: COMPLETED

CONTRACT START DATE: 83 10 26 COMPLETION DATE: 84 02 17

CONTRACTOR:
Ontario Research Foundation
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PRINCIPAL INVESTIGATOR:
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NRC PROJECT MANAGER:
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(613) 993-9224

NRC PROJECT SCIENTIST:
P. Sparrow
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(613) 993-9224

CONTRACT PRICE:
$12 254

FUNDING AGENCY:
Solar Energy Program
National Research Council
Bldg. R-92, Montreal Road
Ottawa, Ontario, K1A 0R6

PROJECT PRECIS:

As a result of the Contract with Ontario Research Foundation (DSS File No. 05SX.31155-2-2791) on "Experimental Evaluation of Solar Domestic Hot Water System Test Procedures," it was concluded that because of the solar simulator and other testing facilities already in place, the National Solar Test Facility (NSTF) is an ideal laboratory to undertake the testing of SDHW systems on a routine, year-round basis.

To this end, this contract was issued on a sole source basis to define the exact requirements, plans, specifications, and cost estimates for modifying and/or extending the National Solar Test Facility in order to allow testing of both solar domestic hot water systems and photovoltaic panels and systems for the Canadian solar industry.

The resulting report examines, in depth, the expansion required in working space, changes needed in the existing building, and the improvements, relocation, and additions needed to plant equipment. Detailed specifications, drawings, and cost estimates have been developed for the recommended 10 x 17 m extension to NSTF.

REPORTS AND REFERENCE SOURCES: A project digest is available on loan from the Canada Institute for Scientific and Technical Information (Energy Library), National Research Council, Bldg. R-105, Ottawa, Ontario, K1A 0S2. The main contract report contains proprietary specifications, and hence is not available for public distribution.

KEY WORDS: Solar, National Solar Test Facility, NSTF, extension, DHW, testing

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